Bioversity International

FINAL REPORT

Introduction, Evaluation, and Adoption of Improved and Superior Landraces of Banana for Food and Income Alleviation

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TERMINAL REPORT

A. BASIC INFORMATION

1. Project Title: Introduction, Evaluation and Adoption of Improved and Superior Landraces of Banana for Food and Income Alleviation

   Sub-project 1. Establishment of a National Repository, Multiplication and Dissemination Center (NRMDC) at the Institute of Plant Breeding, U.P. Los Baños

   Sub-project 2. Establishment of a National Repository, Multiplication and Dissemination Center (NRMDC) at the Bureau of Plant Industry - Davao National Crop Research and Development Center (BPI-DNCRDC)

2. Proponent: Bioversity International
   Commodities for Livelihoods- Asia Pacific Office
   3/F Khush Hall, IRRI, Los Baños, Laguna 4031, PHILLIPPINES

3. Implementing Agency

   Lead Agencies:

   Sub-project 1: National Plant Genetic Resources Laboratory
   Crop Science Cluster (CSC)
   Institute of Plant Breeding (IPB)
   College of Agriculture (CA)
   University of the Philippines Los Baños (UPLB)

   Sub-project 2: Bureau of Plant Industry (BPI)-
   Davao National Crop Research and Development Center (DNCRDC)
   Bago Oshiro, Davao City

4. Project Duration: January 1, 2005 – June 30, 2008

5. Project Locations: Institute of Plant Breeding (IPB)
   College of Agriculture (CA)
   University of the Philippines Los Baños (UPLB)

   Davao National Crop Research and Development Center DNCRDC), Bago Oshiro, Davao City

6. Project Funding
    6.1. Total Approved Budget: USD 150,000
    6.2. Total Amount Released USD 150,000
    6.3. Actual Expenses

B. TECHNICAL DESCRIPTION

1. ABSTRACT

Two National Repository, Multiplication and Distribution Centers were established in the country: one at the University of the Philippines Los Baños (UPLB)in Laguna, and another at the Bureau of Plant Industry (BPI) located in Davao. The Centers maintain the 23 cultivars introduced from the International Transit Centre in cultures and in the greenhouse. These Centers also serve as the source of introduced and local cultivars for distribution to researchers, students and farmers. A total of 18,459 tissue-culture derived plantlets had been distributed to interested users.

The introduced cultivars were evaluated in terms of their agronomic and yield performance and the results were published in a catalogue. Assessment for their resistance to major diseases (banana bunchy top, black sigatoka, Fusarium wilt and nematodes) was also conducted. Sensory evaluation to determine the acceptability of the introduced cultivars was done in three (3) sites, and during the farmers' field day. Among the introduced cultivars, FHIA 17 and FHIA 21 were identified with good potential for processing into banana chips and cake. In addition, FHIA 03 and FHIA 23 were also recommended for planting in Mindanao due to its high yield and acceptable taste.

Farmers' field trials were also set up in selected areas in Luzon and Mindanao to promote the utilization of introduced cultivars. In addition, four (4) training courses on the nursery and field management of banana were conducted involving farmers and technicians of the local government units.

The results of the trials were presented in various symposia and meetings, as oral and poster presentations. One (1) oral presentation and eleven (11) poster presentations were presented. One of the posters won the Best Poster (Agricultural Science Category) in the National Academy of Science and Technology Annual Scientific Meeting in 2008. Eight (8) draft manuscripts of the different studies were also written and five (5) exhibit materials were produced.

2. INTRODUCTION

Banana (Musa spp.) is an important crop in the Philippines. It is of many different types including sweet dessert bananas as well as cooking bananas and plantains. In Asia, the Philippines is the second largest banana producer and the number one banana exporter. Except for the export banana, which is a significant source of foreign exchange, the crop is grown largely by smallholder farmers, traded by local entrepreneurs, and consumed locally. Banana therefore plays a major role in food security and income generation for the rural poor. The Philippines, being in the region considered as the center of origin of bananas, boasts of many cultivars such as *Lakatan*, *Latundan*, *Saba*, *Buñgulan* and the export cultivar, Cavendish. Undoubtedly, banana is an important food for Filipinos, source of income for local farmers and an important source of foreign exchange from export.

Small-scale production of non-export bananas has in the past been largely neglected in terms of research and development. Average yields on smallholdings are below 10 tons/hectare/year while commercial plantation farms produce more than 40 tons/ha/year. The major production constraints and threats to the banana industry in the Philippines are pests and diseases. Being at the center of origin of the genus, many serious pests and diseases are also found ravaging the crop. Recent surveys and field visits indicate that many smallholder banana farmers are seriously devastated by epidemics of diseases such as Banana Bunchy Top Virus, Bugtok, Fusarium wilt, as well as Black Sigatoka. The impact of these diseases is especially damaging for smallholder farmers who do not have the economic and technical capabilities to manage these problems. While large plantation owners can control pests and diseases through the use of chemicals, the intensive use of pesticides can adversely affect the environment and human health. The seriousness of the problem is shown by the fact that most of the *Lakatan* and *Latundan* fruits sold in Luzon and Visayas were grown in Mindanao, mostly produced by big commercial growers. This resulted to higher banana consumer price and had removed the traditional source of income to many smallholder banana farmers in Luzon.

This project aimed to make small-scale banana farmers competitive and self sustaining in banana production by making disease-free, improved, and of superior landraces of banana planting materials available to them. The project also trained farmers and stakeholders on proper nursery and field management, generated basic knowledge on the efficiency and benefits of in vitro and in vivo maintenance, established farmers' field trials of promising cultivars, and sustained the source of disease-free planting materials.

The general objective of the project was to enhance the availability of improved, high-yielding and disease-resistant cultivars through the establishment of a National Repository, Multiplication and Dissemination Center (NRMDC) at UPLB. Specifically, the project aimed to: (1) introduce improved, disease-free cultivars that are high yielding and resistant to pests and diseases; (2) establish a National Repository, Multiplication and Dissemination Center (NRMDC) at UPLB and BPI; and (3) establish demonstration trials to showcase availability of improved cultivars and evaluate introduced cultivars as to their agronomic and yield characters, and reaction to common diseases and pests

3. REVIEW OF LITERATURE

Banana ranks first in terms of fruit production (>5.6 Mt) and area harvested (414,510 ha) (BAS 2005) making it the most important fruit crop in the country. It is a significant source of foreign exchange because of its high demand in the export market. However, the majority of the crop is grown by small-holder farmers, and is traded and consumed locally, allowing the banana to play a major role in food security and income generation of the rural poor.

A number of production problems is limiting the Philippine banana industry (PCARRD 1992), foremost of which is the occurrence of destructive diseases. Banana bunchy top virus (BBTV), Bugtok and Fusarium wilt have invaded the banana growing regions of the country and can significantly reduce the yield and quality of bananas produced. These diseases are infecting our local varieties, particularly the Lakatan and Latundan cultivars, and have resulted in farmers abandoning the growing of these cultivars. Black sigatoka was reported to reduce yield by as much as 80% in small farmers' fields (Eusebio et al. 2003). Other production problems include inadequate production and post-production practices, predominance of subsistence backyard plantings, poor marketing systems, and lack of quality standards for fresh and processed products for local cultivars.

Over the years, Musa researchers worldwide have developed a number of new, high-yielding and disease-resistant banana cultivars (MGIS 2006). These improved cultivars are now ready for distribution and are being made available for testing to small-holder farmers by the Commodities for Livelihoods Programme of Bioversity International (Bioversity), formerly International Network for the Improvement of Banana and Plantain/International Plant Genetic Resources Institute (INIBAP/IPGRI) (dela Cruz et al. 2007). The National Plant Genetic Resources Laboratory (NPGRL) of the Crop Science Cluster-Institute of Plant Breeding (CSC-IPB), University of the Philippines Los Baños (UPLB) and Davao National Crop Research ad Development Center of the Bureau of Plant Industry were identified to serve as the National Repository, Multiplication and Distribution Centers (NRMDC) of improved hybrids and superior landraces of banana. These Centers will make available to local growers improved, high-yielding and disease-resistant banana cultivars introduced from the Musa International Transit Centre in Belgium through Bioversity.

Since 2002, the NRMDC has received in vitro plantlets of introduced banana cultivars for conservation and testing. The availability of these improved cultivars and superior landraces from foreign sources to the local banana industry is a shortcut to a long, tedious and expensive banana breeding program. It is believed that the introduction of these new cultivars as a component of an integrated crop management strategy involving the use of clean planting materials, could have a rapid and significant impact on levels of production of banana in the Philippines.

4. METHODOLOGY

Sub-project 1. Establishment of a National Repository, Multiplication and Dissemination Center (NRMDC) at the Institute of Plant Breeding, U.P. Los Baños

Study 1. *In vitro* and *in vivo* maintenance and multiplication of improved and superior banana cultivars

Activity 1.1 Maintenance of repository for banana foundation stocks

Five to ten *in vitro* cultures of the introduced and local banana varieties were maintained in the rooting (MS basal medium) and multiplication medium (MS basal medium + 3 mg/L BAP). Cultures were sub-cultured onto fresh medium regularly every two months. The *in vitro* collection serves as source of materials for multiplication and distribution. Suckers of the different varieties collected from the Mainit, Pili Drive, and IPB Greenhouse (IPB GH) were established *in vitro* following the established banana micropropagation protocol (Damasco and Barba, 1984). All materials were indexed for the presence of banana virus before culture initiation. The initial culture response such as degree of culture browning and multiplication rates were determined.

In vivo maintenance. Introduced and local banana cultivars were planted in plastic pots (#14) filled with sterilized potting medium (garden soil: coconut coir dust, 1:1v/v) and kept inside an insect-proof greenhouse of IPB. Each cultivar will have 5 plants grown individually in plastic pots. The plants were given optimum care to ensure normal growth and development. Monitoring for morphological changes or somaclonal variation as well as presence of pests and diseases was done.

An experiment was conducted to determine the conditions for continuous maintenance of foundation stocks inside the greenhouse. Pseudostems of 20 introduced and local banana cultivars were cut at 2 different heights: 12 inches and 6 inches above the soil level. A total of 81 plants were used in this experiment. Of these, 37 and 44 plants were cut at 12 inches and 6 inches above the soil level, respectively. Cutting of the pseudostems was done when the longest leaf touched the ceiling of the 3 meters high screen enclosure. Plant height (cm) was measured starting at 1 week after cutting using a nylon tape measure. The number of suckers produced by the cultivars was also determined

Activity 1.2 Multiplication and distribution of selected banana cultivars

Banana planting materials needed in Studies 1 and 2 and requests from collaborators and interested clients were multiplied using the established micropropagation protocol. Proliferated cultures were transferred every three to four weeks. Nine selected varieties (FHIA 1, 2, 17, 18, 21, 23, Lakatan Davao, Cardaba and Quarenta Dias) were multiplied in bigger quantities and the remaining 22 varieties in limited quantities.

Study 2. Promotion and farmers' field trial of selected banana cultivars

Activity 2.1. Establishment and maintenance of demonstration fields

Two banana demonstration fields were established. The first demonstration field was established at the IPB Experiment Station located in Bgy. Paciano Rizal, Mainit, Bay, Laguna in October 2002 and consisted of 19 introduced hybrids and landraces and eight local cultivars (including 4 accessions of Lakatan). The demonstration field serves as a showcase of the different banana cultivars and has been visited by farmers, researchers, students and other interested individuals. Morphological characterization of the cultivars was conducted following the standard Descriptors for Banana.

The second demonstration field was established at the Central Experiment Station of UPLB in February 2005. It consisted of six introduced and six local cultivars. In addition to serving as a showcase of selected introduced and local banana cultivars, these materials are also being evaluated for agronomic and yield characters, as well as their acceptability to growers and consumers and reactions to common diseases and pests (as component activities of Study 3).

Activity 2.2 Promotion of banana cultivars through establishment of farmers' field trial

Farmers' field trials were set up in selected areas in Luzon. The trials were made on three introduced (FHIA 17, FHIA 21 or FHIA 25 and FHIA 23) and two local (Cardaba and Lakatan Davao) cultivars with 20 plants per replication. The experiment was set up with two replications and laid out using Randomized Complete Block Design (RCBD). Cultural management applied was based on farmers' practice. Data gathered includes agronomic (plant height, days to flowering, days to harvesting and days from flowering to harvest) and yield data (bunch weight, number of hands and fingers per bunch and average fruit weight).

Planting materials distributed to farmers, research institutions, non-government organizations (NGOs) and local government units (LGUs) were monitored by the project staff.

Activity 2.3 Sensory evaluation

Nine local and twenty introduced bananas cultivars were used in the sensory evaluation. The table bananas were eaten ripe with *Lakatan* or *Latundan* as the control. Cooking bananas were boiled with Saba or Cachaco as the control.

Three towns with one barangay each from Laguna were used as testing sites. These were the areas suggested by the respective Municipal Agriculture offices.

A total of 62, 32, and 74 participants, respectively from Bunggo, Putho-Tuntungin and Sta. Cruz, participated in banana sensory evaluation. Four sessions each were performed in Bunggo and Sta. Cruz while three were done in Putho-

Tuntungin.

Sample bananas were allowed to ripen to eating stage and were brought to the testing sites. The ratings were entered in evaluation sheets bearing 10 qualities to describe the banana sample.

The participants were shown a hand of each the samples for the shape, peel color and relative size of banana and plantain fingers. Each of the participants was given a finger of each of the sample. The pulp was evaluated after peeling. The taste, flavor, sweetness and texture were scored from the peeled banana sampled at the middle and two ends of the finger cut with a plastic knife and placed in plastic plates. The samples were picked using toothpick. The participants were provided with water for washing the mouth in every sampling.

Another sensory evaluated was conducted 15 March 2006 during the farmers' field day. A total of 99 participants joined the evaluation. Five different types of banana preparations were included in the test, namely ripe boiled, ripe uncooked, cake, salted chips and honeyed chips. The same set of introduced hybrid bananas were used in different preparations. Different local banana cultivars were used as control or reference in various preparations.

Cut samples (~0.5 cm) for ripe uncooked and boiled banana preparations while a slice (~2.5 x 3 cm) of cake were tested by the participants. Banana chips were placed as small sachets prepared by Zenaida Corcuera Food Products. Water was provided as mouth wash in between test samples.

The participants were asked to note the taste and after all samples of every preparation, were asked to rank the bananas from highest to lowest (1- highest, 7 or 9 lowest). Prepared data sheets were provided for every participant.

Study 3. Evaluation of local and introduced banana cultivars for resistance to major diseases

Sub-study 3.1 Resistance of banana cultivars to banana bunchy top (BBT)

Activity 3.1.1 Screening of local and introduced banana cultivars to banana bunchy top

Local and introduced banana cultivars were planted in two separate sites at UPLB. First set consisting of five local cultivars and 14 introduced cultivars were planted at the Institute of Plant Breeding Banana Demostration Farm, Brgy. Paciano Rizal, Bay, Laguna using double row method, at 20 plants per cultivar, while in the second set, five local cultivars and six introduced cultivars (FHIA lines) were planted at the Central Experiment Station, Pili Drive, UPLB, College, Laguna on February 3, 2006 using double row method, at 14 plants per cultivar.

In the first set, local cultivars were Lakatan (Lakatan-Cavite, Lakatan-Davao, Lakatan-Mindoro, Lakatan Mindoro Saba), Bungulan, Cavendish, Cuarenta Dias and Cardaba while the introduced cultivars were FHIA lines (FHIA 01, FHIA 023, FHIA 17, FHIA 18, FHIA 22 and FHIA 23), Yangambi Km 5, SH 3436-9, Williams,

Pisang Jari Buaya, Cachaco, Pisang Ceylan, SH 3640, AACV rose, GCTCV 119, CRBP 39, Gros Michel, TMB x 1378 and TMB x 5295-1. In the second set, local cultivars were Lakatan (Lakatan-Cavite, Lakatan-Davao), Latundan, Cavendish, Cardaba and Cuarenta Dias, and the FHIA lines were FHIA 01, FHIA 02, FHIA 17, FHIA 18, FHIA 23 and FHIA 25.

The incidence of banana bunchy top disease (BBTD) and the type and severity of symptoms on introduced and local cultivars planted in the first set were recorded. In the second set, only the incidence of BBTD was recorded starting from the five months after planting until 19 months. In both experiments, there were no artificial inoculation done and plants showing BBTV symptoms were roughed.

The role of asymptomatic banana plants on the spread of the disease in the field was determined. Suckers of apparently healthy cultivars from Laguna, Quezon, Cavite and Batangas where incidence of BBTD was very high were collected and brought to IPB and grown in the screenhouse. Suckers were planted in plastic pots until they develop leaves. Leaf samples were tested for the presence of BBTV using ELISA to determine whether the BBT virus is present or not.

Activity 3.1.2 Resistance to *Pentalonia nigronervosa*, the insect vector of BBTV

Tissue-cultured plantlets of banana with varying reactions to BBTV were used in the experiment. Ten banana varieties (one plant per variety) were randomly and equidistantly placed in an insect-proof cage with P. nigronervosa source at the center. Aphid count was done at regular interval from seven to 45 days after exposure to insect population. Colony count was done to determine the rate of reproduction of insect vector in each variety.

Activity 3.1.3 Mechanism of resistance to BBTV

The resistance of different local and introduced varieties of banana to virus multiplication was analyzed. Tissue-cultured plantlets of varieties with varying reactions to BBTV were used in the experiment.

A viruliferous aphid was allowed to feed on infected plant overnight to acquire the virus (acquisition access feeding period). Aphids were given an overnight inoculation access feeding period, after which spraying of insecticide was done to kill all the insects in the inoculated plants. All the inoculated and uninoculated control plants were placed and maintained in an insect-proof cage. Plants were regularly monitored for symptom expression. Data on incubation period, disease severity and percent infection were gathered.

Asymptomatic test plants were analyzed to determine the presence of the virus. Transmission tests and enzyme linked immunosorbent assay (ELISA) were employed to determine the titer of the virus in asymptomatic plants.

Sub-study 3.2 Evaluation of banana cultivars against nematodes

Activity 3.2.1 Assessment of nematode infection under natural condition

All cultivars planted in the banana demonstration field at Brgy. Paciano Rizal was evaluated for their response to nematodes. Root samples from each replicate were collected and root damage assessment was conducted to include percentage dead roots, percentage root necrosis, root-knot galling index and egg laying females index. The number of nematodes inside the root samples was counted and percentage distribution and percentage in the population were determined.

Activity 3.2.2 Confirmatory screening of banana cultivars for resistance to nematodes under greenhouse condition

Tissue cultured plantlets were evaluated for resistance to root knot caused by *Meloidogyne incognita* (UPLB isolate) and root necrosis by *Radopholus similis* (Quezon isolate) under greenhouse condition. For *M. incognita*, each plant of the 10 local and introduced cultivars was inoculated with 5,000 eggs/juveniles. On the other hand, individual plants of 11 local and introduced cultivars were inoculated with 1,000 juveniles of *R. similis*. Inoculation was done on one month-old plants while evaluation was done two months after inoculation. Cultivar Cavendish served as the susceptible check for both nematodes. Growth parameters (plant height (cm), pseudostem girth at base (cm), shoot weight (g) and root weight (g) of uninoculated plants (without inoculation) were compared with those inoculated with either *M. incognita* or *R. similis*. Percentage reduction due to nematodes was taken. For *M. incognita*, the root galling index (0 – no galls, 1 – trace infection with very few scales, 2 - <25% of roots galled, 3 – 25-50% of roots galled, 4 – 51 to 75% of roots galled, 5 - >75% of roots galled) was taken while for *R. similis*, percentage dead roots and root necrosis of five 10-cm root segments, were taken. For both nematodes, the number of juveniles or larvae per gram of roots was taken. Application of fertilizer and spraying of insecticides were done.

Sub-study 3.3. Evaluation of cultivars against sigatoka and other important diseases

Activity 3.3.1. Evaluation for resistance to sigatoka leaf spot

All cultivars were evaluated for resistance to Sigatoka leaf spot during harvest stage. Individual leaf was examined for the presence of lesions of Sigatoka. Disease severity or the amount of leaf area affected by the disease, was expressed as a grade (0 to 6) using Gauhl's modification of Stover's scale (Gauhl,

1994). The following data were gathered: number of standing leaves, youngest leaf spotted (YLS), or the leaf number of the youngest leaf with 10 or more mature lesions, infection index (II), index of youngest leaf spotted (IYLS) and index of non-spotted leaf area (INSL). Infection index (II), IYLS and INSL were taken using the following formula:

$$\text{Infection Index (II)} = \frac{\Sigma nb}{(N-1)T} \times 100$$

where: n = number of leaves in each grade
b = grade
N = number of grades used in the scale (7)
T = total number of leaves scored

$$\text{IYLS} = \frac{T - YLS\text{-}1}{T} \times 100$$

where: YLS = youngest leaf spotted
T = total number of leaves

$$\text{INSL} = \frac{YLS - 1}{NLS} \times 100$$

where: YLS – youngest leaf spotted
NSL – number of standing leaves

Resistance was evaluated based on youngest leaf spotted where >10 – highly resistance, 8.5 – 9.9 – resistant, 6.0 – 8.5 – susceptible, < 6.0 – very susceptible (INIBAP, 1996).

Activity 3.3.2. Evaluation for resistance to Fusarium wilt

Incidence of suspected Fusarium wilt in cultivar Latundan was noted nine months after planting. The area was visited and evaluated. External symptoms were noted. The pseudostem was cut and examined. Affected tissues were collected and brought to the laboratory for isolation. The isolate was purified in potato dextrose agar and inoculated to tissue cultured cv Latundan using blended mycelial fragments to test its pathogenicity.

Activity 3.4 Evaluation of banana cultivars for incidence of arthropod pests

Cultivars planted at banana demonstration field at CES, UPLB were assessed for incidence of arthropod pests. The cultivars attacked by the pests were recorded. Banana cultivars planted in the greenhouse were also monitored for the presence of arthropod pests.

Sub-project 2. Establishment of a National Repository, Multiplication and Dissemination Center (NRMDC) at the Bureau of Plant Industry - Davao National Crop Research and Development Center (BPI-DNCRDC)

Study 1. Establishment of NRMDC under screenhouse

The NRMDC was established at the Bureau of Plant Industry-Davao National Crop Research and Development Center, Bago Oshiro, Davao City in November, 2003. The Center serves as the source of materials for multiplication and distribution to interested farmers and researchers. It establishes and maintains the improved and superior cultivars as foundation stocks inside an insect-proof screenhouse using 0.05 mm mesh screen. The screenhouse used was 3.5 meters high, 10 meters wide and 20 meters long.

Tissue-cultured plantlets of improved and superior cultivars from the International Transit Center (ITC) in Belgium were multiplied in the laboratory for six months. Plantlets were then transferred to potting trays filled with decomposed saw dust or coir dust covered with plastic transparent cellophane for one (1) week acclimatization. Two (2) weeks after, potted plantlets were transferred individually to 6 cm X 8 cm black polyethylene plastic bag with a potting media ratio of 5 parts decomposed coir dust and 10 parts saw dust. After two to three months, these were planted in 52 cm diameter with a height of 48 cm clay pots with a potting media of one part compost (coir dust), one part fine river sand and three parts garden soil, and kept inside the screenhouse.

Cultural management

Maintenance of the plants was done by regular fertilization of urea for the first four months. From the fifth month onwards, complete fertilizer was applied once a month. Sanitation was regularly employed by removing dry leaves and sheaths.

Pesticides such as Decis, Karate and other insecticides were sprayed when insects were observed in the plants. Fungicides (Dithane, Copper fungicides and Koecides) were also applied for leaf diseases twice a month.

Pruning was done once a year to maintain a manageable height. When the plant height reached 180 centimeters banana plants were cut back, leaving 30 centimeters from the base.

To determine the BBTV health status, leaf samples were subjected to serological indexing using the antibody from the National Taiwan University (c/o Dr. Su) and the University of the Philippines, Los Baños, Laguna (c/o Dr. Bajet).

Distribution/Multiplication

Selected cultivars in the foundation stocks were multiplied through tissue culture for mass production. These were distributed to interested farmers, researchers and collaborators.

Study 2. Establishment of Field Demonstration Plot

Randomized Complete Block Design (RCBD) with 13 accessions/cultivars (8 introduced hybrids, 2 local accessions and 3 Taiwan cultivars), were replicated three (3) times with 14 plants per accession at a planting distance of 2 meters between plants and 3 meters between rows. Drainage canals of 40 centimeters deep separate the two-row per replicate (Figure 1).

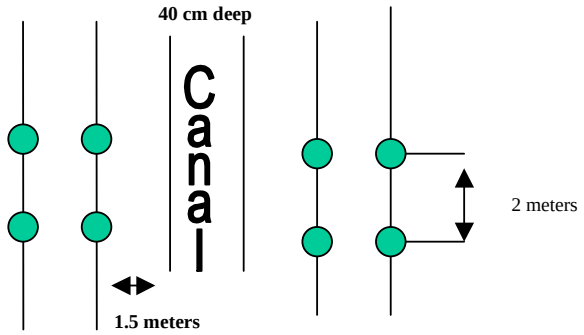


Figure 1. Planting design of the demonstration plot established at the DNCRDC, Bago Oshiro

Cultural Practices

Twenty-five (25) grams of urea was applied per plant during field establishment. Four (4) weeks after planting, 85 g of urea was supplied per mat; after 8 weeks, 110 g of urea was again supplied per mat. Six to eight months thereafter, complete fertilizer and Muriate of Potash were applied to condition the plants for bunch emergence/flowering and fruiting. Other cultural management practices were also implemented such as desuckering and ring weeding to ensure proper growth and development of all test plants for evaluation. All plants were managed according to conventional practices such as sanitation (de-leafing and removal of dry bracts) and removal of male buds (10 cm below the false or last hand). Weedicide spraying was also implemented when necessary. No agrochemicals were used to control the diseases and pests. The area was not irrigated since it was rain-fed. Watering was done when necessary.

Data collection

Agronomic traits

Plant height was measured from the ground to the junction between the two youngest leaves, the number of functional leaves (70% leaf area green) and the number of days from planting to shooting were recorded at flowering/shooting stage.

Yield performance of the improved banana landraces was evaluated. The time from planting to harvest was also recorded. The girth of the pseudostem at 1 m

above the ground and the number of functional leaves were also determined and recorded. At harvest, bunch stalk (peduncle) was cut above the first hand at the level of the last scar and immediately below the last hand. Bunch weight, the number of hands per bunch, total number of fingers and fruit weight in a bunch were recorded.

Bukidnon

Site establishment

Tissue cultured plantlets from INIBAP-ITC as well as selected promising local cultivars were multiplied for field testing. Four (4) cooking banana, dessert and plantain hybrid cultivars (FHIA-03, FHIA-18, FHIA-21, FHIA-23) and two (2) local check cultivars (Cardaba and Lakatan) were laid out in a Randomized Complete Block Design (RCBD) using ten (10) plants per cultivar, replicated three (3) times.

The trial was established on a 0.252 hectare area at Jocel's Farm in Brgy. San Carlos, Valencia City, Bukidnon.

The study adopted the farmer's double row planting design. The plants were spaced 2 meters between hills, 1.5 meters between furrows and 4 meters between double rows. The farmer utilized the 4-meter distance between double rows by intercropping corn (Figure 2).

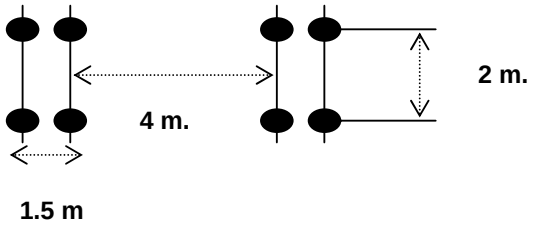


Figure 2. Planting design of yield trial of conducted in farmers' field in Bukidnon

Management Practices

The experimental area was plowed and harrowed twice. Holes were dug and were sterilized by burning rice hull in the holes prior to planting. Regular weeding, irrigation and fertilization were done as necessary. The farmer adopted the general fertilizer rate of 0.30 kg Urea and 0.30 kg Potash per mat per year. Lime was applied to the area prior to planting. The area was periodically harrowed to improve soil texture.

Mat population was maintained at one mother plant and 2 followers after flowering. Sucker control was done when the first follower is one meter high or during shooting of the mother plant. Male bud removal was also practiced.
Prior to eradication of infected test plants due to diseases, the area was sprayed with insecticide and herbicide to control the population of insect vectors and alternate weed hosts of insect vectors, respectively.

Data collection

General information of the farm, disease incidence, agronomic data and post harvest characteristics of new cultivars were recorded.

Study 3. Evaluation for pests and diseases

Activity 3.1 Evaluation for resistance to Fusarium wilt

International Musa Testing Programme (IMTP)

Site of Experiment

The evaluation was conducted at the experimental station of the Bureau of Plant Industry in Bago Oshiro, Davao City, Mindanao. The experimental site is located at 70 07550' N and 1250 49654' E which has an elevation of 133 masl. The topography of the site corresponds to a plain with clay loam soil texture and soil pH of 6.7. Soil drainage is good.

Nursery Management

In-vitro propagated plantlets were transferred to potting trays filled with decomposed pure coir dust and covered with transparent cellophane for acclimatization. After two (2) weeks in potting trays, plantlets were removed and transferred to 6cm x 8cm black polyethylene plastic bags individually. The media contained a ratio of 5 parts decomposed coir dust and 10 parts decomposed saw dust. The plantlets were kept inside the screen house for 3 weeks. Application of fertilizer to the plantlets and watering were done when needed.

Field Establishment

When the plants were already acclimatized for field condition, they were planted in the field, using Complete Randomized Design (CRD) with 23 treatments (cultivars) and 20 replications (plants) at a planting distance of 2.5m x 2.5m. For Pisang Jari Buaya, Aa cv Rose, Yangambi km 5 and FHIA-03, only 10 replications were planted.

At planting, the plants received 25 g urea per plant. Repeat application of complete fertilizer at 250g per mat was done after three (3) months. Other cultural management practices implemented were de-leafing, de-suckering, weeding and debelling. Herbicide spraying was also done when necessary.

An experimental site was selected for the establishment of different accessions for the Musa Testing Program for Fusarium. Field establishment was done using the guidelines from INIBAP. Different accessions for testing were received from the collection of KUL, Belgium. Table 1 shows list of the Musa accessions included for testing against Fusarium wilt.

Collection of Data

The INIBAP guidelines for evaluation of Musa germplasm for resistance to Fusarium wilt were followed.

Monitoring in the field was done three (3) months after planting. Accessions that showed external symptoms as well as internal symptoms were recorded. Infected plants that showed external symptoms were rated following the rating scale provided by INIBAP, where: scale 1= symptoms absent; scale 2= symptoms present. Internal symptom as to the extent of the vascular discoloration in the pseudostem was measured and recorded. Corm discolorations of the suckers were also rated based on the rating scale of 1-6.

Harvested accessions were recorded. Agronomic characteristics of these accessions such as the height of the sucker at shooting, the bunch weight, the number of hands, number of fingers, size of girth, and the fruit weight were also recorded. Plant height of the follower was also recorded at shooting stage. Fruit characteristics of the accessions were also recorded. Environmental data obtained from the Agrometeorological Center, Bago Oshiro, Davao City were recorded.

Table 1. List of accessions used for field testing against Fusarium wilt.

Cultivar	Cultivar
FHIA 02	SH 3640
FHIA 03	SH3436-9
FHIA 17	CRBP 39
FHIA 23	Pisang Ceylan
FHIA 25	Cachaco
FHIA 18	Gros Michel
FHIA 21	Yangambi km 5
TMBx1378	Aa cv Rose
TMBx 5295-1	Pisang Jari Buaya
TMB 3x 15-108-6	Williams
	Latundan

Monitoring of planting materials distributed to commercial plantations

Planting materials of the introduced cultivars GCTCV 119 and GCTCV 247, which were identified to be resistant to Fusarium wilt, were distributed to the commercial plantations such as Lapanday, Stanfilco and Uni-Fruiti. The areas were visited and monitored if there were occurrence of the disease.

Activity 3.2 Evaluation for resistance to Sigatoka

International Musa Testing Programme III

Study Site

The trial was planted on August 2-3, 2002 at the Bureau of Plant Industry -Davao National Crop Research and Development Center in Bago Oshiro, Davao City, Mindanao. The experimental site is located at 7o 32' N and 125o 50' E at an elevation of 112 masl. The soil pH is 6.7. The topography of the site corresponds to plain with a clay loam soil texture. It belongs to the inceptisols type. Soil drainage is good. Climatic conditions were favorable for disease development.

Nursery establishment

In-vitro propagated plantlets were transferred to potting trays containing decomposed pure coir dust and covered with transparent cellophane for acclimatization. After two weeks from the potting trays, the plantlets were removed and transferred to 6 x 8 cm black polyethylene bags individually. The media contained a ratio of 5 parts decomposed coir dust and 10 parts decomposed saw dust. The plantlets were kept inside the screenhouse. Application of fertilizer to the plantlets and watering when needed were done. When the plants were already acclimatized with field conditions, they were then transferred to the field.

Field establishment

The plants were arranged in a Randomized Complete Block Design (RCBD) with 16 treatments (cultivars): 14 introduced hybrids from ITC Belguim, and 2 local accessions from the Philippines (Table 2) and 5 blocks with 5 plants per replication at a planting distance of 2.5 meters between plants and 3 meters between rows. Previously planted Williams were rehabilitated by cutting the established plants one meter from the ground. These served as spreader rows of the fungal pathogen.

At planting, the plants received 25g urea per plant. Four (4) weeks after planting, 85 g of urea were supplied per mat. After 8 weeks, 110 g of urea were again supplied per mat. Complete fertilizer and Muriate of Potash were applied to condition the plant for bunch emergence/flowering and fruiting, six to eight months after planting. Other cultural management practices were also implemented to the experimental area such as desuckering and ring weeding, to ensure proper growth and development of all test plants for evaluation. Weedicide spraying was also implemented when necessary. The area was not irrigated since it was a rain-fed area. Watering was done when necessary.

Data collection

After three (3) months of planting, tagging and rating of the plants were done for in-depth evaluation. The INIBAP guidelines for the screening of *Musa* germplasm for resistance to Sigatoka were followed with some adjustments to local conditions and practices.

Table 2. List of introduced and local Musa accessions for field trial against Sigatoka.

ITC #	ACCESSION
0506	FHIA 03
1319	FHIA 18
0504	FHIA 01
1332	FHIA 21
1418	FHIA 25
0505	FHIA 02
1344	CRBP-39
1123	Yangambi Km 5
1907	SH-3640
1297	TMB X 5295 – 1
1296	TMB X 1378
1441	P. Ceylan
1417	TMB X 15108-6
0312	P. Jari Buaya
Local check	Lakatan
Local check	Cardaba

Disease Development Time (DDT)

Plants were inspected once a week. The plants with cigar leaves nearing Brun's Stage B were tagged and marked with the corresponding date. The tagged cigar leaves were inspected once a week until ten or more discreet mature, necrotic lesions or one large area with ten or more light colored dry center were visible. The data were recorded when mature lesions appeared.

Youngest Leaf Spotted (YLS)

Counting from the top of the plant to the bottom, the youngest leaf spotted (YLS) is the number of the first unfurled leaf with ten (10) discreet, mature necrotic lesions or one large necrotic area with ten (10) light colored dry centers. This information was recorded for each leaf that has been assessed for disease development time (DDT). After shooting, when the leaves cease to be produced, the YLS values were recorded at weekly intervals until harvest.

Disease severity

Leaves were scored for disease levels by using Gauhl's modification of Stover's system. Percentage of the leaf area affected by the Sigatoka pathogen expressed in disease grades (1 to 6) was recorded for each leaf on each plant. This information was recorded at six months after planting, at bunch emergence (shooting) and at harvest. The number of leaves that have photosynthetic activity and those that had more than 50% of green area is to be considered functional at the bunch emergence/shooting stage and at harvest. Buckling leaves (asterisk *) are those that have more than 50% of green area, dead leaves (D) in upright and dead leaves in buckling (*D) were also recorded.

Agronomic data

The time between planting to shooting and harvest were recorded. Plant height from the ground to the junction between the two youngest leaves, the girth of the pseudostem at 1 m above the ground and the number of functional leaves that have photosynthetic activity and leaf that has more than 50% of green area were considered. These were recorded at the shooting and at harvest stages. Agronomic data were also taken at harvest, bunch stalk (peduncle) were cut above the first hand at the level of the last scar and immediately below the last hand. Bunch weight, the number of hands per bunch, the hand weight and numbers of fingers per hand were recorded except the fruit characteristics.

Climatic data were also collected from the Philippine Coconut Authority Agromet/weather station in Bago Oshiro, Davao City.

Study 4. Performance evaluation against pests and diseases

Activity 4.1 Banana Bunchy Top Virus (BBTV)

Incidence of Banana Bunchy Top Virus (BBTV)

Monitoring of banana bunchy top virus (BBTV) and its aphid vector in the field previously planted with introduced and local accessions/cultivars from IMTP area were done. Accessions/cultivars that were infected with BBTV symptoms were recorded.

Banana Bunchy Top Virus (BBTV) survey by rapid indexing

Survey and collection of banana samples were done within the station from Cardaba and Lakatan plantings. Ten apparently healthy and six BBTV-infected samples of Cardaba and Lakatan were collected. Samples were collected from the upper unfolded younger leaves using the midrib for indexing. The samples were placed in polyethylene bags soon after collection.

Samples were cut into strips and placed in tubes and extraction buffer was added. Samples were then mashed with bamboo sticks. BBTV test strips were dipped on each tube until reaction appears.

Transmission Experiment

In-vitro propagation of banana cultivars

In-vitro propagation of 10 banana accessions/cultivars, consisting of 8 introduced (FHIA 1, 2, 3, 17, 18, 21, 23, and 25,) and 2 local accessions (Lakatan and Cardaba) used in the experiment was done using shoot culture. At cycle 5 of proliferation, plantlets were planted in trays to acclimatize for at least 1-2 weeks. Plantlets were bagged individually and maintained inside the screenhouse until ready for transmission experiment.

Culture of insect vectors for BBTV transmission

Prior to inoculation experiments, the population of *P. nigronervosa* was multiplied. Aphid viviparous females were introduced to healthy banana plant and allowed to produce progenies/nymphs. After 24 hours the nymphs were transferred to healthy banana plants and were allowed to develop and reproduced to provide virus free population of the vectors. The plants were kept inside insect proof screen cages to prevent re-infection.

Transmission of the virus using P. nigronervosa

Aphids from the stock culture were allowed to feed on BBTV infected leaves for 12 – 24 hours (acquisition feeding). The aphids were transferred to the healthy test plants (5-6 leaf stage) at ten aphids per plant and were allowed to feed for another 24 hours (infection /inoculation feeding). After infection feeding, insecticide was sprayed on the test plants to kill the aphids. The plants were kept inside the screenhouse for symptom observation. Days to first symptom expression were recorded.

Feeding Preference Test

Feeding preference of *P. nigronervosa* was determined under laboratory condition using the excised leaves of the different banana accessions/cultivars. Ten excised leaves (about 1 square inch), corresponding to ten accessions/cultivars were randomly placed inside the pan (10 x 12 inches) in circular pattern.

Three hundred aphids from the stock culture were transferred to the center of the pan. The set-up was placed in a cool area. The aphids were allowed to feed on the plant parts and number of aphids feeding on the excised plant parts of each cultivar was monitored for 1, 2, 4, 8, and 24 hours after aphid transfer.

Activity 4.2 Nematode

Field Survey

Collection of Root Samples

Root samples from FHIA accessions at BPI banana experimental area were collected at shooting and harvesting stage. The collection was carried out following the Technical Guidelines of Speijer and De Waele (1997). A hole of 20x20x20 cm3 was dug next to the stem of the mother plant and all banana roots in this volume were collected and placed in a marked plastic bag.

Root Damage Assessment

The collected root samples were washed with tap water and dried with tissue paper. Roots were divided into dead roots and functional roots and counted the number of roots in each category. Dead roots were shriveled and no healthy

root tissue left. The general health conditions of the secondary and tertiary roots were also assessed. Five functional primary roots, at least 10 cm long were selected then these were cut to 10-cm pieces and the roots were sliced lengthwise. One half of each of the 5 roots were scored for the percentage of the root cortex showing necrosis, the maximum root necrosis per root necrosis per root half was 20%, which gave a maximum root necrosis of 100% for the 5 root halves together.

Nematode Extraction and Assessment of the Nematode Population

Ten grams of root samples were cut into 1 cm length and placed in the kitchen blender with tap water. The root samples were blended three times for 10 seconds (with 5 seconds interval) and poured through 250, 140 and 40 um-pore sieves. Root tissue collected on the 250 and 140 um-pore sieves were discarded while the nematodes were collected from 40 um-pore sieve with distilled water in a beaker. The nematode suspension was diluted to 200 ml with distilled water and air was blown through the nematode suspension with a pipette (to homogenize the suspension). A subsample of 5 ml (counting dish) was taken from the suspension and the nematode was counted in the counting dish under a stereomicroscope. Final nematode population was calculated per root unit and per root system.

Screenhouse Experiment

FHIA hybrids taken from the field genebank of the Bureau of Plant Industry (BPI), Davao City, Philippines were propagated *in vitro* and planted out in pots. After 4 weeks, 10 plants per accession were chosen at random and arranged in a randomized complete block design on an elevated bench inside the greenhouse. Ten plants were inoculated with 1000 vermiforms of *R. similis* per 4 ml while un-inoculated plants served as control. Yangambi Km 5 (AAA) and Grand Nain (AAA) were included in the experiment as the resistant and susceptible check, respectively.

Plants were harvested 8-9 weeks after inoculation (or approximately 3 cycles of R. similis at 20-25 days per cycle) to determine the host-plant reaction

Plant and root parameters were taken immediately after harvesting, following the method described by Speijer and De Waele (1997). The following root data were recorded: nematode counts per 10 g of root sample, root necrosis index and percent dead roots.

The Dunnetts test was used to compare the means of different accessions with the reference materials. The accessions were classified as resistant, partially/moderately resistant or susceptible, modified after Dochez et al. (2006) (Table 3).

Table 3. Identification of the host response of banana genotypes to *Radopholus similis* based on comparison with a resistant and a susceptible reference cultivars.

Comparison with resistant reference – 'Yangambi Km 5'	Comparison with susceptible reference – 'Grand Naine'	Host response of accession
Not significantly different	Significantly different	Resistant
Significantly different	Not significantly different	Susceptible
Significantly different	Significantly different	If value genotype < value 'Yangambi Km 5' ==> Highly resistant If value 'Yangambi Km 5' < value genotype < value 'Grand Nain' ==> Partially resistant If value 'Grand Nain' < value genotype ==> Highly susceptible
Not significantly different	Not significantly different	Inconclusive

Activity 4.3 Weevil

Banana pseudostem weevil incidence in the field

The banana stem weevil (BSW) or banana pseudostem weevil borer *Odoiporus longicollis* Olivier (Coleoptera: Curculionidae) is recently becoming a serious pest of banana. It has been observed that the weevil is associated with rapid decline of banana particularly the small banana farms specifically in Region XI where banana is grown extensively. The adult weevils are black and measures 12-17mm. The pest confines themselves within the pseudostem and in the decomposing tissues of harvested pseudostem. All life stages of the weevil are present in the infested plants throughout the year.

In a survey conducted within Region XI (Davao City, Davao del Norte, Davao del Sur, Davao Oriental, and Compostella Valley) the pest was observed and recorded to be one of the major problems of the farmers. Most of these farms were planted to local cultivars like the Cardaba, Lakatan and Latundan. Generally, high infestation of the banana pseudostem weevil was observed in Davao del Norte where majority of the resource-limited small farmers are cultivating banana as a subsistence crop. High population or resurgence of the weevil in small banana farms could be attributed to the poor management

practices employed with very minimal inputs. The farmers are unable to undertake chemical pesticide intervention on a regular basis.

The pest was generally observed to be more of a problem on poorly managed farms where weak plants are unable to compensate for damage. However, the pest was also observed damaging the improved banana cultivars planted at the BPI demonstration plot. The initial infestation was observed and recorded in FHIA 23 and FHIA 21.

5. RESULTS AND DISCUSSION

Sub-project 1. Establishment of a National Repository, Multiplication and Dissemination Center (NRMDC) at the Institute of Plant Breeding, U.P. Los Baños

Study 1. *In vitro* and *in vivo* maintenance and multiplication of improved and superior banana cultivars

Activity 1.1 Maintenance of repository for banana foundation stocks

In-vitro establishment and maintenance

A total of 30 banana varieties, composed of 23 introduced and 7 local varieties are maintained *in vitro* using the shoot culture technique (Table 4). Cultures are maintained in the rooting and multiplication medium. Sub-culture onto fresh medium is done regularly every two to three months. The *in vitro* collection serves as source of materials for multiplication and distribution.

In vivo establishment and maintenance

In vivo maintenance. Four (4) plants each of the 31 varieties were planted in big plastic pots and were maintained in the repository greenhouse (Figure 3). These materials served as the foundation stocks for conservation and future micropropagation. All materials maintained in the screenhouse were indexed regularly at most twice a year for the presence of banana viruses.

Eighteen (18) cultivars maintained as foundation stocks were used as test materials to determine the optimum height of cutting of the pseudostem that will allow re-growth at a slower phase. Plants were cut 15 cm (6 inches) and 30 centimeters (12 inches) above the soil level soon as the leaves touched the ceiling of the enclosure. Plants cut at 15 cm showed slower plant growth than plants cut 30 cm starting from the first week after cutting (Table 5, Figures 4 and 5). All cultivars exhibited rapid increase in growth until the second or third week of cutting and slower but steady increase in height at the onset of third or fourth week onwards. At ten weeks after cutting, all cultivars cut at 30 cm above the ground were taller relative to plants cut at 15 cm above the ground, except FHIA 23 which was slightly shorter. It was also observed that newly exerted leaves of those cut at 30 cm tended to bend sideways which caused breakage in some test plants.

Table 4. List of banana varieties introduced from the *Musa* Germplasm Transit Center and local varieties maintained *in vitro* at the National Plant Genetic Resources Laboratory.

ITC Code	Accession Name	Classification (Genome)	Type	Date Introduced	Source
A. Introduced cultivars					
ITC 0312	P. Jari Buaya	Landrace (AA)	Dessert	March 1, 2001	INIBAP
ITC 0504	FHIA-01	Hybrid	Dessert/Cooking	March 1, 2001	INIBAP
ITC 0505	FHIA-02	Hybrid	Dessert/Cooking	March 1, 2001	INIBAP
ITC 0506	FHIA-03	-	-	March 1, 2001	INIBAP
ITC 0570	Williams	Ref. Clone	Dessert	March 1, 2001	INIBAP
ITC 0643	Cachaco	Landrace (ABB)	Dessert/Cooking	March 1, 2001	INIBAP
ITC 0712	AAcv Rose	-	-	March 1, 2001	INIBAP
ITC 1123	Yangambi KM5	Ref. Clone (AAA)	Dessert/Cooking	March 1, 2001	INIBAP
ITC 1264	FHIA-17	Hybrid	Dessert/Cooking	March 1, 2001	INIBAP
ITC 1265	FHIA-23	-	Dessert/Cooking	March 1, 2001	INIBAP
ITC 1282	GCTCV-119	Somaclonal Variant (AAA)	Dessert	March 1, 2001	INIBAP
ITC 1283	SH 3436-9	Somaclonal variant	Dessert	March 1, 2001	INIBAP
ITC 1296	TMBx 1378	Hybrid	Cooking	March 1, 2001	INIBAP
ITC 1297	TMBx 3295-1	Hybrid	Dodo	March 1, 2001	INIBAP
ITC 1307	SH 3640	Hybrid	Dessert/Cooking	March 1, 2001	INIBAP
ITC 1319	FHIA-18	Hybrid	Dessert	March 1, 2001	INIBAP
ITC 1332	FHIA-21 (#68)	Hybrid	Plantain/Cooking	March 1, 2001	INIBAP
ITC 1344	CRBP 39	Hybrid	Plantain/Cooking	March 1, 2001	INIBAP
ITC 1418	FHIA-25	-	-	February 26, 2005	CavSU
ITC 1441	Pisang Ceylan	Primitive cv. (AAB)	Dessert	March 1, 2001	INIBAP
ITC 1122	Gros Michel	Ref. Clone (AAA)	Dessert	Oct. 29, 2002	Lapanday
ITC 1442	GCTCV 106	-	-	Oct. 29, 2002	Lapanday
ITC 1443	GCTCV 247	-	-	Oct. 29, 2002	Lapanday
B. Local cultivars					
-	Cavendish	AAA	Dessert	April 4, 2002	Lapanday
-	Cardaba	BBB	Cooking	April 4, 2002	Lapanday
-	Bungulan	AAA	Dessert	April 4, 2002	Lapanday
-	Lakatan Davao	AA	Dessert	April 4, 2002	Lapanday
-	Lakatan Cavite	AA	Dessert	Dec. 17, 2001	Cavite
	Quarenta Dias	AA	Dessert	Nov. 2001	Bataan
-	Latundan	AAB	Dessert	Sept. 28,2005	Sta Maria, Laguna

This may be due to the narrower girth of re-grown pseudostem that cannot support the long and huge newly formed leaves. These results indicate that cutting the pseudostem at a lower portion would result to slower growth and produce more vigorous re-growth and which would result to longer cutting time.

Suckering ability was not affected by the cutting treatments but appeared to be influenced by genotype, as shown in Table 6.

Introduction and in vitro establishment of improved banana varieties

Two hundred thirteen (213) disease-free suckers of 15 introduced and six (6) local varieties collected from the field demonstration plots and greenhouse repository were cultured in vitro following the established micropropagation protocol (Table 4). Initial cultures of FHIA 21, TMBX 1378, CRBP 39 and Latundan showed moderate browning and slight nubbin formation. On the other hand, initial cultures of Cardaba exhibited severe browning. The newly initiated cultures from other varieties showed very slight browning and exhibited good multiplication rate

Activity 1.2 Multiplication of select varieties of banana

1.2.1 Improvement of the micro-propagation protocol for FHIA 21

FHIA 21 cultured *in vitro* following the standard micro-propagation protocol showed severe browning of both media and explants for the initial culture and very poor shoot/bud regeneration. Response was limited to enlargement of corms/buds and only 50% of cultures showed enlarged corm/buds (Table 9). Severe browning of explants resulted to death of cultures. Regular sub-culture onto fresh multiplication medium every four weeks slightly reduced the degree of browning. However, very slight improvement in the regeneration was observed. Results indicate that the standard medium for banana is not suitable for FHIA 21.

The micro-propagation protocol was modified by using MS + 5 mg/L medium for the initial culture followed by use of low concentration (1mg/L) of different cytokinin sources for subsequent sub-cultures. The use of lower concentration of cytokinin reduced the browning of the media and explant and showed higher % of cultures with regeneration of both shoots and buds (Table 7). Subsequent sub-culture cycles further reduced browning and increased shoot and bud regeneration. The problem of enlargement of corm and buds was minimized with the use of lower cytokinin concentration. The buds and nubbins produced regenerated into shoots in subsequent sub-culrture cycles. The improved micropropagation protocol for FHIA 21 consisted of initial culture on MS + 5 mg/L BAP (standard medium) followed by sub-culture into lower concentration (1 mg/L) of either BAP kinetin or 2IP since shoot regeneration and/or proliferation was almost the same for the three cytokinin sources. With this modified protocol, higher multiplication rate was obtained for FHIA 21.

Figure 3. Foundation stocks of introduced and local banana cultivars conserved inside the greenhouse.

Table 5. Plant height (cm) of banana cultivars cut at 6 and 12 inches above the soil level and taken at weekly intervals.

Cultivar name	Week 1		Week 2		Week3		Week 4		Week 5		Week 6		Week 7		Week 8		Week 9		Week 10	
	6"	12"	6"	12"	6"	12"	6"	12"	6"	12"	6"	12"	6"	12"	6"	12"	6"	12"	6"	12"
A. Introduced cultivars																				
CRBP 39	10.20	23.90	14.90	45.90	14.90	49.00	15.00	56.55	-	58.35	-	59.60	-	60.60	-	61.30	-	62.90	-	68.15
FHIA 01	15.97	26.95	27.83	42.05	39.23	48.50	40.33	49.95	44.43	50.25	47.65	52.88	51.56	54.73	53.86	57.21	54.77	60.29	55.39	-
FHIA 02	14.22	28.50	26.27	38.60	32.37	46.03	32.10	47.15	34.20	47.71	35.43	51.60	42.50	53.45	44.47	54.35	45.03	56.31	46.41	57.84
FHIA 17	19.13	28.35	40.07	47.35	45.00	50.90	45.07	51.35	47.90	51.65	54.99	63.14	61.09	64.50	61.89	67.35	62.61	68.43	64.33	70.36
FHIA 18	14.93	25.55	38.03	48.00	52.00	48.60	48.80	48.30	51.50	50.60	53.85	60.14	56.56	62.78	56.28	63.29	57.66	64.14	57.66	66.22
FHIA 23	13.15	31.05	39.45	48.21	44.45	57.30	45.75	58.55	49.50	58.85	55.01	61.15	61.93	62.70	64.12	62.95	67.85	67.30	70.34	69.80
GCTCV 106	22.00	25.10	36.06	49.50	47.50	57.00	49.07	58.00	52.00	59.10	54.00	61.90	54.00	63.00	54.00	65.10	53.80	66.00	54.20	69.70
GCTCV 247	11.50	28.10	25.75	52.20	32.05	55.80	39.95	59.60	41.35	62.10	45.75	67.75	49.00	73.45	51.85	73.05	57.10	73.55	59.95	73.65
Gros Michel	24.70	31.00	24.90	50.70	25.40	52.90	28.10	54.10	30.70	-	33.60	-	36.80	-	39.50	-	40.80	-	48.50	-
SH 3436-9	14.70	26.23	35.90	47.80	42.60	48.20	44.45	48.60	45.35	48.80	45.95	48.90	47.65	48.90	49.35	54.20	51.15	58.00	51.30	60.40
SH 3640	12.10	29.73	33.90	54.13	37.40	56.53	40.50	61.27	47.10	62.30	47.90	71.99	48.60	74.44	51.80	75.61	56.50	77.63	60.80	79.39
TMBx 1378	35.57	33.60	46.85	56.10	56.28	62.00	63.85	64.80	-	66.70	-	67.20	-	68.60	-	72.20	-	76.20	-	80.20
Williams	25.14	45.14	35.28	48.71	44.07	52.85	54.29	52.98	-	-	-	-	-	-	-	-	-	-	-	-
B. Local cultivars																				
Cardaba	16.90	22.15	33.05	35.80	44.20	48.95	47.77	57.38	49.83	63.10	52.33	63.40	54.65	64.90	59.20	68.10	62.67	71.70	65.47	74.80
Cavendish	11.00	29.13	25.00	50.03	36.70	56.53	38.40	56.97	38.90	58.21	39.43	61.37	40.28	60.59	40.57	63.10	40.57	65.05	41.00	66.60
Lakatan	10.80	34.87	22.50	50.00	25.70	53.43	30.00	53.00	37.80	54.10	43.60	56.32	47.35	60.53	48.50	63.93	51.40	69.23	52.10	72.97
Cavite Lakatan	14.91	30.50	41.60	58.28	44.45	63.70	48.80	64.55	52.50	64.85	56.51	66.12	59.30	67.65	60.23	71.04	60.95	73.74	61.40	74.14
Davao Latundan	13.70	28.00	37.30	53.00	52.15	54.80	63.40	55.20	69.15	55.25	72.90	70.80	75.60	74.10	77.18	76.80	78.60	79.30	79.80	85.10

Figure 4. Comparative heights of plants cut at 15 cm and 30 cm above the ground.

a. FHIA-01 cut at 15 cm (left) and FHIA-01 cut at 30 cm (right)) after 1 week
b. Cavendish cut at 15 cm (left) and Cavendish cut at 30 cm (right) after 2 weeks

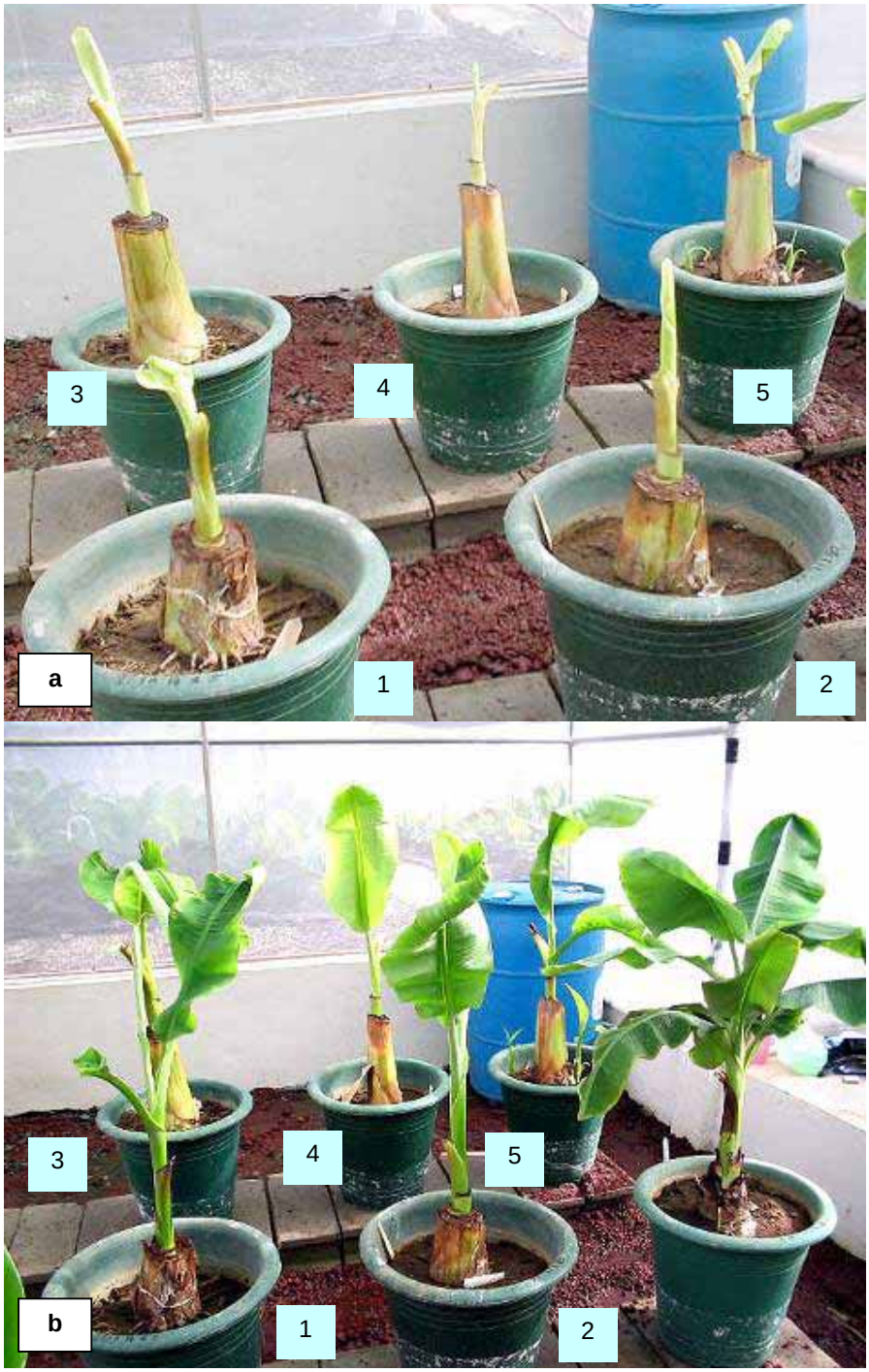


Figure 5. Comparative heights of plants cut at 15 cm (foreground) and at 30 cm (background) after 1 week (a) and two weeks (b) of cutting.

1 FHIA-17
2 FHIA-18
3 SH 3640
4 FHIA-01
5 Cavendish

Table 6. Suckering of banana cultivars cut at 6 and 12 inches from the soil level.

Cultivar Name	No. of plants		No. of suckers before cutting (Ave.)		No. of suckers at 10 weeks after cutting (Ave.)	
	6"	12"	6"	12"	6"	12"
A. Introduced cultivars						
CRBP 39	1	2	0.00	0.00	0.00	0.00
FHIA-01	3	2	0.67	0.00	1.33	0.50
FHIA-17	3	2	0.33	0.00	1.67	2.00
FHIA-18	3	2	0.00	0.00	1.67	2.50
FHIA-02	4	2	0.00	0.00	1.25	0.50
FHIA-23	2	2	0.00	0.00	2.50	2.00
GCTCV 106	1	1	2.00	0.00	2.00	2.00
GCTCV 247	2	2	1.50	0.67	2.50	2.50
Gros Michel	1	1	0.00	0.00	3.00	0.00
SH 3436-9	2	1	1.00	1.00	2.00	1.00
SH 3640	2	3	0.50	0.00	1.00	1.00
TMB X 1378	1	1	0.00	0.00	1.00	0.00
Williams		1		2.00	-	2.00
B. Local cultivars						
Cardaba	3	2	0.00	0.00	0.00	0.00
Cavendish	1	3	1.00	1.00	1.00	2.33
Lakatan	2	3	1.00	0.00	1.50	1.33
Cavite Lakatan	3	2	0.67	1.00	1.00	1.00
Davao Latundan	2	1	0.00	0.00	1.50	1.00

Table 7. Banana varieties cultured *in vitro* following the standard banana micropropagation protocol.

Variety	Number of suckers cultured (source of suckers)*	Initial culture response	Multiplicatio n Rate**
FHIA-01	5 (IPB GH)	No browning	2
FHIA-03	5 (IPB GH	No browning	1
FHIA-17	30 (Mainit, IPB GH)	No browning	3
FHIA-18	13 (IPB GH)	No browning	3
FHIA-21	47 (Mainit)	Severe to moderate browning, nubbin formation	1
FHIA-23	45 ((Mainit, IPB GH)	No browning	3
FHIA-25	10 (CavSU)	No browning	3
Williams	5 (IPB GH)	No browning	3
AACV ROSE	9 (IPB GH)	No browning	3
KM 5	10 (IPB GH)	No browning	3
TMBX 1378	5 (IPB GH)	Moderate browning, nubbin formation	2
CRBP 39	5 (IPB GH)	Moderate browning, nubbin formation	2
GCTV-106	5 (IPB GH)	No browning	3
Gros Michel	5 (IPB GH)	No browning	3
PJB	10 (IPB GH)	Moderate browning, nubbin formation	2
Lakatan Davao	5 (Pili Drive)	No browning	3
Bungulan	10 (IPB GH)	No browning	3
Cardaba	50 (Mainit)	Severe browning	2
Cavendish	10 (IPB GH)	No browning	3
Latundan	15 (Tranca)	Moderate browning, nubbin formation	2

*Source- IPB GH -IPB greenhouse repository; CavSU - Cavite State University

**Multiplication Rate: 1- slight', 1-2 shoots produced/ shoot/cycle; 2- moderate- 3-5 shoots produced/shoot/cycle, 3- good- >5 shoots produced/shoot/cycle

Table 8. *In vitro* culture response of FHIA 21 cultured using the standard micropropagation protocol (MS medium + 5 mg/L BAP).

Culture Cycle	Degree of media browning*	Degree of explants browning*	Response (% of cultures)*		
			Enlarged corm/buds	Small buds	Shoot
Initial culture (SC0)	severe	severe	0	0	0
Sub-culture cycle 1 (SC1)	severe	severe	50	50	0
Sub-culture cycle 2 (SC2)	severe	severe	50	50	0
Sub-culture cycle 3 (SC3)	moderate	moderate	100	100	0

*Measurements taken from mean of 24 initial shoot cultures

1.2.2 Multiplication of improved and superior banana varieties

Nine (9) selected varieties consisting of six FHIA accessions (FHIA 01, 02, 17, 18, 21 and 23) and three (3) local varieties (Lakatan Davao, Cardaba, Quarenta Dias) were multiplied in bigger quantities for distribution to farmers and interested growers. The remaining 21 varieties were multiplied in limited quantities for research purposes. The eight varieties (FHIA 01, 02, 17, 18, 23, Lakatan Davao, Quarenta Dias) showed good to excellent multiplication with the standard medium (MS + 5 mg/L BAP) while FHIA 21 and Cardaba showed good shoot proliferation with the modified medium (MS + 5 mg/L BAP for initial culture and MS + 1 mg/L BAP, kinetin or 2IP for the subsequent sub-culture cycles) (distributed to state colleges and universities, Department of Agriculture units, non government organizations, farmers and interested growers (Table 10). The *in vitro* proliferated cultures were distributed to institutions with tissue culture capability for further multiplication of materials while rooted plantlets were given to organizations and individuals trained on handling tissue cultured plantlets for nursery establishment. Established seedlings ready for fields planting were given to farmers and growers.

For *in vitro* plantlets, the state colleges and universities (SCUs) received the highest number of plantlets (3,983) followed by DA and other government agencies (2,033). While for established plantlets, farmers and farmers groups received the biggest number (Table 10).

1.2.3 Distribution

For the whole project duration, 9,171 in vitro plantlets (rooted and proliferated cultures) and 9,288 established plantlets or a total 18,459 tissue cultured plantlets were distributed. The most number of planting materials were distributed to SCUs (5,608), followed by farmers and farmer groups (4,364), project research (3,205), and DA and other attached agencies (3,075). Ten SCUs were included in the list of recipient/end-users; the most number of plantlets were distributed to Isabela State University (1,134 plantlets) and Nueva Viscaya State University (962 plantlets).

In terms of number of plantlets distributed per variety (Table 11), for the introduced varieties, FHIA 17 had the most number of plantlets distributed (3,607 plantlets), followed by FHIA 23 (1,678 plantlets), FHIA 21 (1,533 plantlets) and FHIA 02 (1,197 plantlets). For the local varieties, Lakatan Davao had the most number of plantlets distributed (2,908 plantlets) followed by Cardaba (1,674plantlets) and Quarenta Dias (617 plantlets).

Table 9. *In vitro* culture response of FHIA 21 cultured using the modified micropropagation medium[1]

Culture medium	Media/Explant browning	Response (% of cultures)[2] Enlarged corm/buds (Ave. Number of enlarged corm/buds)	Small buds (Ave. Number of small buds)	Shoots (Ave. Number of shoots)
Sub-culture cycle 1				
MS + 1 mg/L BAP	moderate	100 (4)	100 (2)	57 (2)
MS + 1 mg/L Kinetin	moderate	100 (5)	71 (5)	71 (5)
MS + 1 mg/L 2ip	moderate	100 (4)	71 (2)	57 (1)
Sub-culture cycle 2				
MS + 1 mg/L BAP	moderate	100 (5)	100 (4)	85 (2)
MS + 1 mg/L Kinetin	moderate	100 (5)	71 (3)	85 (3)
MS + 1 mg/L 2ip	moderate	100 (2)	100 (3)	100 (1)
Sub-culture cycle 3				
MS + 1 mg/L BAP	slight	100 (6)	100 (4)	100 (6)
MS + 1 mg/L Kinetin	slight	100 (6)	100 (6)	100 (4)
MS + 1 mg/L 2ip	slight	100 (4)	100 (4)	100 (3)

[1]Initial culture on MS + 5 mg/L BAP
[2]Measurements taken from mean of 14 initial shoot cultures

Table 10. Banana tissue cultured planting materials distributed to different end-users for research, field trials and field plantings.

End-user/Recipient	*In vitro* plantlet			Established plantlet			TOTAL 3 years
	Year 1&2	Year 3	Total	Year 1&2	Year 3	Total	
Municipal/provincial agriculture office (LGU)	0	660	660	331	266	597	1,257
DA and other government agencies	60	1,973	2,033	272	770	1,042	3,075
Farmers and farmer groups	50	535	585	1,297	2,482	3,779	4,364
State Colleges and Universities (SCUs)	1,220	2,743	3,963	884	761	1,645	5,608
Interested private individuals	20	360	380	155	415	570	950
Project research	1,050	500	1,550	1,255	400	1,655	3,205
TOTAL	2,400	6,771	9,171	4,194	5,094	9,288	18,459

Table 11. Total number of *in vitro* and established plantlets distributed per variety

Cultivar	*In vitro*	Established	TOTAL
A. Introduced			
FHIA-01	150	442	592
FHIA-02	535	662	1,197
FHIA-03	50	57	107
FHIA-17	2,383	1,224	3,607
FHIA-18	495	185	680
FHIA-21	909	674	1,533
FHIA-23	499	1,179	1,678
FHIA-25	59	356	415
Williams	40	126	166
COCHACO		31	31
AACV ROSE		32	32
KM 5	100	106	206
PJB	370	120	490
GCTV-119	100	41	141
SH-3436-9	32	40	72
TMBX3295-1	35	57	92
TMBX 1378	33	32	65
Pisang Ceylan	50	50	100
CRBP 39	400	38	438
GCTV-106	350	129	479
GCTV-247	105	37	142
SH-3640	54	42	96
Gros Michel	54	36	100
B. Local			
Lakatan Davao	1,041	1,867	2,908
Lakatan Cavite		81	81
Bungulan	245	83	328
Cardaba	420	1,259	1,674
Quarenta Dias	507	110	617
Cavendish	145	122	267
Latundan		70	70
Sub Total	9,171	9,288	18,459

Study 2. Promotion and farmers' field trial of selected banana cultivars

Activity 2.1. Establishment and maintenance of demonstration field and promotion of selected banana cultivars

The banana cultivars maintained at the banana demonstration field in Mainit, Bay, Laguna were characterized using the standard Banana Descriptors. From this activity, a catalogue of introduced and local banana cultivars was developed, which is available in hard and electronic copy at the Bioversity International. The Catalogue contains full description and representative pictures of the local and introduced cultivars. In addition, a manuscript titled, "Agronomic and Yield performance of Introduced and Popular Local Banana Cultivars (*Musa* spp.) in the Philippines" was published in the Philippine Journal of Crop Science Volume 34 No. 1. pp 88-98.

A second banana demonstration field was established in February 2005 at the Central Experiment Station, UPLB. This served as a showcase on superior introduced cultivars and has been visited by farmers, researchers, students and other interested individuals (Figures 6 and 7).

The agronomic and yield data of introduced and local banana cultivars from the demonstration field are presented in Table 12. Cavendish was the earliest to flower (213.67 days) while FHIA 25 was the last to flower (380.29 days). However, Cuarenta dias was the earliest to harvest from planting (279.35) and the earliest to harvest from flowering (47.70 days) while FHIA 25 was the last to harvest from planting (521.29 days) and the last to harvest from flowering (141 days). FHIA 25 also produced the heaviest bunch (47.49 kg per bunch), most number of hands (15.05 hands per bunch) and most number of fingers (277.86 fingers). For the local cultivars, Cavendish produced the heaviest bunch (23.44 kg) while Cardaba produced the most number of hands (8.61) and most number of fingers (149.98). The introduced cultivars produced heavier bunches than the local cultivars, except FHIA 18 and FHIA 01.

The cultivars planted in the CES demonstration field were observed to mature earlier and produce better than the same cultivars established in the earlier demonstration field in Mainit, Bay, Laguna.

A collaborative activity with a local food manufacturer (Z. Corcuera Food Products, Mayondon, Los Baños, Laguna) was initiated. The project supplied fruits of FHIA cultivars harvested from the banana demonstration field and was processed into banana chips with honey (Figure 8). Initial assessment by the owner indicated that FHIA 01, FHIA 02, FHIA 17 and FHIA 21 were better in terms of eating quality compared to Saba, the common local cultivar used for processing banana chips. The main limitation of the FHIA cultivars (FHIA 18 in particular) is the rapid browning of the fruit which can be managed by immediately cooking the fruits right after slicing.

A local fruit stall owner also ventured to sell FHIA cultivars together with the local cultivars and found that FHIA 02 and FHIA 17 were acceptable in terms of taste and size with the local consumers and foreigners (Figure 9).

Figure 6. Banana demonstration field established at the Central Experiment Station, UPLB.

Figure 7. The Banana Demonstration Field is often visited by farmers, students and other interested individuals.

Table 12. Agronomic and yield data of introduced and local banana cultivars planted at the Demonstration Field, CES, UPLB.

Cultivar	No. of days to flowering*	No. of days to harvest*	No. of days from flowering to harvest*	Bunch weight* (kg)	No. of hands*	No. of fingers*
A. Introduced cultivars						
FHIA 01	230.33 ab	363.92 cd	133.58 d	22.22 d	8.70 de	125.96 ef
FHIA 02	245.59 abc	343.72 bc	98.13 b	24.30 d	9.05 d	129.88 ef
FHIA 17	320.37 de	419.52 ef	99.15 b	36.61 b	12.25 b	200.56 c
FHIA 18	274.29 bc	400.13 de	125.85 cd	21.38 d	8.42 de	133.17 e
FHIA 23	353.23 ef	448.89 fg	95.66 b	31.79 c	11.28 c	217.72 b
FHIA 25	380.29 f	521.29 h	141.00 d	47.49 a	15.03 a	277.86 a
B. Local cultivars						
Quarenta dias	231.65 ab	279.35 a	47.70 a	8.51 g	7.24 f	110.00 h
Cavendish	213.67 a	306.81 ab	93.14 b	23.44 d	8.08 e	128.45 ef
Latundan	258.52 abc	354.04 c	95.51 b	12.39 f	7.18 f	101.07 h
Cardaba	338.77 ef	479.39 g	140.62 d	23.19 d	8.61 de	149.98 d
Lakatan Davao	289.21 cd	382.35 cde	93.14 b	17.24 e	6.84 f	115.71 gh
Lakatan Cavite	273.10 bc	379.37 cde	106.26 bc	18.03 e	6.70 f	109.80 h

* Means in column of the same letter are not significantly different at 5% DMRT level

Activity 2.2 Promotion of banana cultivars through establishment of farmers' field trial

Four farmer-cooperators were selected to set-up the farmers' field trial. Selection of the farmer-cooperators was coursed through the U.P. Pahinungod and State University located at the province, to facilitate project monitoring and gathering of data. The field trial was established using the same cultivars, planting lay-out and data to be gathered. Cultural management applied depends on farmers' own practices. The first trial was done in November 11, 2005 while the fourth trial was conducted in January 17, 2006.

The following are the farmer-cooperators who planted the banana trial and the location of the farm:

1. Name of farmer-cooperator: Dr. Allan C. Genato
   Location of farm: Brgy. Busilak, Bayombong, Nueva Viscaya
   Date of planting: November 11, 2005

2. Name of farmer-cooperator: Mr. Fermin A. Mulimbayan
   Location of farm: San Antonio, Los Banos, Laguna
   Date of planting: November 23, 2005

3. Name of farmer-cooperator: Mr. Manolo O. Camo
   Location of farm: Philippine High-Value Commercial Crops Research and Training Center-Provincial Agricultural Services, Buang, Tabaco City, Albay
   Date of planting: December 22, 2005

4. Name of farmer-cooperator: Mr. Leon D. Agcanas
   Location of farm: Brgy. San Manuel, Echague, Isabela
   Date of planting: January 17, 2006

Figure 8. Collaboration with a local food manufacturer (Z Corcuera Food Products) was initiated to produce banana chips from the introduced FHIA cultivars.

Figure 9. FHIA 17 being sold in the fruit stand, together with local banana cultivars, in Los Baños, Laguna.

A demonstration plot of the different introduced and local cultivars were also established at the Philippine Rice Research Institute (PhilRice) as a component crop of the PALAYAMANAN project. In addition, on-station trials were established at the Nueva Viscaya State University (NVSU) in Bayombong and at the Isabela State University (ISU) Jones Campus.

Activity 2.3 Sensory evaluation

Sensory evaluation in three testing sites

Among the FHIA hybrids considering all the traits, FHIA-23 was the most preferred while FHIA-18 was the least preferred except for pulp texture wherein FHIA-21 was preferred over other cultivars while FHIA-17 was the least preferred. Among the local cultivars, Lakatan Davao was the most preferred in terms of pulp texture, taste, flavor, sweetness, followed by Lakatan Cavite which was the preferred cultivar in terms of finger shape, peel color and finger size.

Considering all the hybrids and cultivars, Lakatan Cavite was the most preferred based on finger shape and peel color while FHIA-18 was preferred last. Cavendish was preferred last among the local cultivars. FHIA-23 was the most preferred among the FHIA hybrids. Considering all the introduced bananas only, Pisang Ceylan was the most preferred while FHIA-18 was the least preferred.

In terms of finger size, TMB x 52-95-1 was the most preferred while AACV Rose was last. Among the local cultivars, Lakatan Cavite was the most preferred while Quarenta Dias was the least preferred. Both AACV Rose and Cuarenta dias produce small fingers.

Lakatan Mindoro is most preferred in terms of pulp color while that of FHIA-18 was the least. For the introduced cultivars, SH 3640 was the most preferred while FHIA-18 was the least preferred. The pulp color of Latundan was the least liked among the local cultivars.

For pulp size, TMB x 5295-1 was the most preferred while that of AACV Rose was the least. Among the local cultivars, Lakatan MIndoro-1 was the most preferred while Cuarenta Dias was the least.

For pulp texture, FHIA-21 was the most preferred among introduced cultivars while Lakatan Davao was preferred among the local cultivars. Williams and Lakatan Cavite had the lowest rating among the introduced and local cultivars, respectively.

When the bananas were ranked according to taste, Lakatan Davao and FHIA 23 were the most preferred among the local and introduced cultivars, respectively. Cavendish and FHIA-18 were rated last among the local and introduced cultivars. The same trend was observed in terms of pulp flavor, banana pulp sweetness and overall acceptability.

Taste test of the different preparations of Banana conducted during the Farmers' Field Day

Saba was more preferred as boiled followed by FHIA-18 and FHIA-17. FHIA-23 was the least liked as boiled banana.

Among the introduced banana hybrids prepared as cake, FHIA-01 was the most preferred while FHIA- 25 was the least liked. All FHIA hybrids except FHAI-23 and FHIA-25 surpassed Cavendish as the preferred raw material for cake.

All FHIA hybrids except FHIA 25 were more preferred than Saba as honeyed chips. FHIA-18 and FHIA-17 were preferred as honeyed chips followed by FHIA-01 and FHIA-02.

FHIA-01 was best liked as salted chips while FHIA-02 was the least. All of the FHIA hybrids were more preferred than Saba as salted chips.

The ripe uncooked introduced banana hybrids did not compare with the local cultivars Lakatan Cavite and Lakatan Davao although all hybrids but FHIA-25 were more preferred than Cuarenta Dias. FHIA-25 was comparable to Cuarenta Dias.

Study 3. Evaluation of local and introduced banana cultivars for resistance to major diseases

Sub-study 3.1. Resistance of banana cultivars to banana bunchy top (BBT)

Activity 3.1.1 Resistance of Local and Introduced Banana Cultivars to Banana Bunchy Top

A. Banana bunchy top incidence at Mainit, Bay, Laguna

Among the introduced cultivars planted at IPB Demo Farm, Mainit, Bay, Laguna, percentage BBT incidence was highest on SH 3436-9 (59.7%), followed by Pisang Jari Buaya (37.0%) and FHIA 02 (33.3%) (Table13). Among the local cultivars, Cuarenta Dias had the highest percentage incidence (88.0%), followed by Lakatan Mindoro (50.7%) and Cavendish (45.3%). Two introduced cultivars had low percentage incidence, namely TMB X 1378 (1.7%) and TMB X 5259-1 (9.0%). Regarding the rate of disease increase, TMB x 1378, Cachaco, CRBP 39, TMB X5259-1 and Pisang Ceylan, had the lower rate than the other introduced cultivars. It was also worthy to note that seven introduced cultivars got infected 23 months after planting, while the rests got infected earlier. Among the local cultivars, only Bungulan became infected 20 months after planting, while the rest became infected much earlier. In all local cultivars, rate of BBTD increase was fast. Some of the plants showed symptoms of the disease at flowering stage and on suckers that were produced. Differences on the types and severity of BBT symptoms were observed on the different cultivars (Table 14, Figure 10). Symptoms of marginal chlorosis of young leaves, … [continue after tables and figures]

Table 13. Percentage incidence of banana bunchy top on different banana cultivars grown at IPB Demo Farm, Brgy. Paciano Rizal, Mainit, Bay, Laguna.

Cultivar	Percent Incidence			
	17 MAP	20 MAP	23 MAP	30 MAP
A. Introduced				
FHIA 01	0	10.3	10.3	18.7
FHIA 02	1.7	1.7	6.7	33.3
FHIA 17	0	8.7	16.7	16.7
FHIA 18	5.3	8.7	12.0	17.0
FHIA 21	0	10.0	18.0	23.5
FHIA 23	1.7	5.0	5.0	28.3
Williams	3.4	12.3	19.0	19.0
Gros Michel	0	11.3	13.0	13.0
GCTCV 119	6.8	10.0	24.0	32.3
SH 3640	0	8.3	12.7	21.7
SH 343-9	0	16.0	54.7	59.7
Yangambi Km5	0	10.0	16.7	25.3
AACV Rose	0	6.0	13.3	26.3
Pisang Jari Buaya	0	10.3	24.3	37.0
Cachaco	0	5.3	7.0	13.7
TMB X 1378	0	1.7	1.7	1.7
TMB X 5259	0	5.7	9.0	9.0
CRBP 39	0	5.0	5.0	10.0
Pisang Ceylan	0	8.7	10.3	10.3
B. Local				
Cardaba	0	14.3	17.7	17.7
Bungulan	0	18.3	32.0	32.0
Lakatan-Cavite	3.4	6.7	10.3	41.0
Lakatan-Davao	1.8	8.7	22.3	33.3
Lakatan-Mindoro	8.7	7.0	38.3	50.7
Lakatan-Mindoro (Saba)	3.5	8.7	24.7	30.3
Cavendish	2.8	18.7	26.3	45.3
Cuarenta Dias	6.7	10.3	67.7	88.0

MAP – months after planting

Table 14. Types and severity of symptoms of banana bunchy top exhibited by the different banana cultivars grown at IPB Demo Farm, Brgy. Paciano Rizal, Mainit, Bay, Laguna

Cultivar	Type and Severity of Banana Bunchy Top Symptoms
A. Introduced	
Yangambi KM 5	slight marginal chlorosis, leaf narrowing, moderate stunting
Pisang Jari Buaya	slight marginal chlorosis, slight leaf narrowing, twisting & distortion, severe stunting
SH 3436-9	marginal chlorosis, leaf narrowing & upward curling, severe stunting, necrosis
SH 3640	slight marginal chlorosis, leaf narrowing & twisting, severe stunting, necrosis
Cachaco	slight marginal chlorosis, slight leaf narrowing & upward curling, severe stunting
Pisang Ceylan	marginal chlorosis, leaf narrowing & twisting, severe stunting
AACV Rose	marginal chlorosis, leaf narrowing & twisting, severe stunting, necrosis
GCTCV 119	slight marginal chlorosis, leaf narrowing, twisting & distortion, severe stunting, necrosis
TMB X 5295-1	marginal chlorosis, slight leaf narrowing, slight stunting
CRBP 39	slight marginal chlorosis, leaf narrowing & twisting, severe stunting
FHIA 01	marginal chlorosis, leaf narrowing, twisting & distortion, severe stunting
FHIA 02	marginal chlorosis, leaf narrowing, upward curling & twisting, severe stunting
FHIA 17	marginal chlorosis, leaf narrowing, twisting & distortion, moderate stunting
FHIA 18	marginal chlorosis, leaf narrowing, twisting & distortion, severe stunting
FHIA 21	marginal chlorosis, leaf narrowing, upward curling & twisting, severe stunting, necrosis
FHIA 23	marginal chlorosis, leaf narrowing, twisting & distortion, severe stunting, necrosis
Williams	slight marginal chlorosis, slight leaf narrowing, twisting & distortion, severe stunting
Gros Michel	marginal chlorosis, leaf narrowing, upward curling & twisting, severe stunting
Giant Cavendish	marginal chlorosis, leaf narrowing, upward curling & twisting, severe stunting
B. Local	
Cardaba	severe marginal chlorosis, leaf narrowing & upward curling, moderate stunting, necrosis
Bungulan	marginal chlorosis, leaf narrowing & twisting, severe stunting, necrosis
Quarenta Dias	severe marginal chlorosis, leaf narrowing, twisting & distortion, severe stunting, severe necrosis
Lakatan Cavite	slight marginal chlorosis, leaf narrowing, & twisting, severe stunting, necrosis
Lakatan Davao	severe marginal chlorosis, leaf narrowing, twisting & distortion, severe stunting, necrosis
Lakatan Mindoro I	margina;l chlorosis, leaf narrowing, twisting & distortion, severe stunting, necrosis
Lakatan Mindoro II	marginal chlorosis, leaf narrowing, twisting, severe stunting

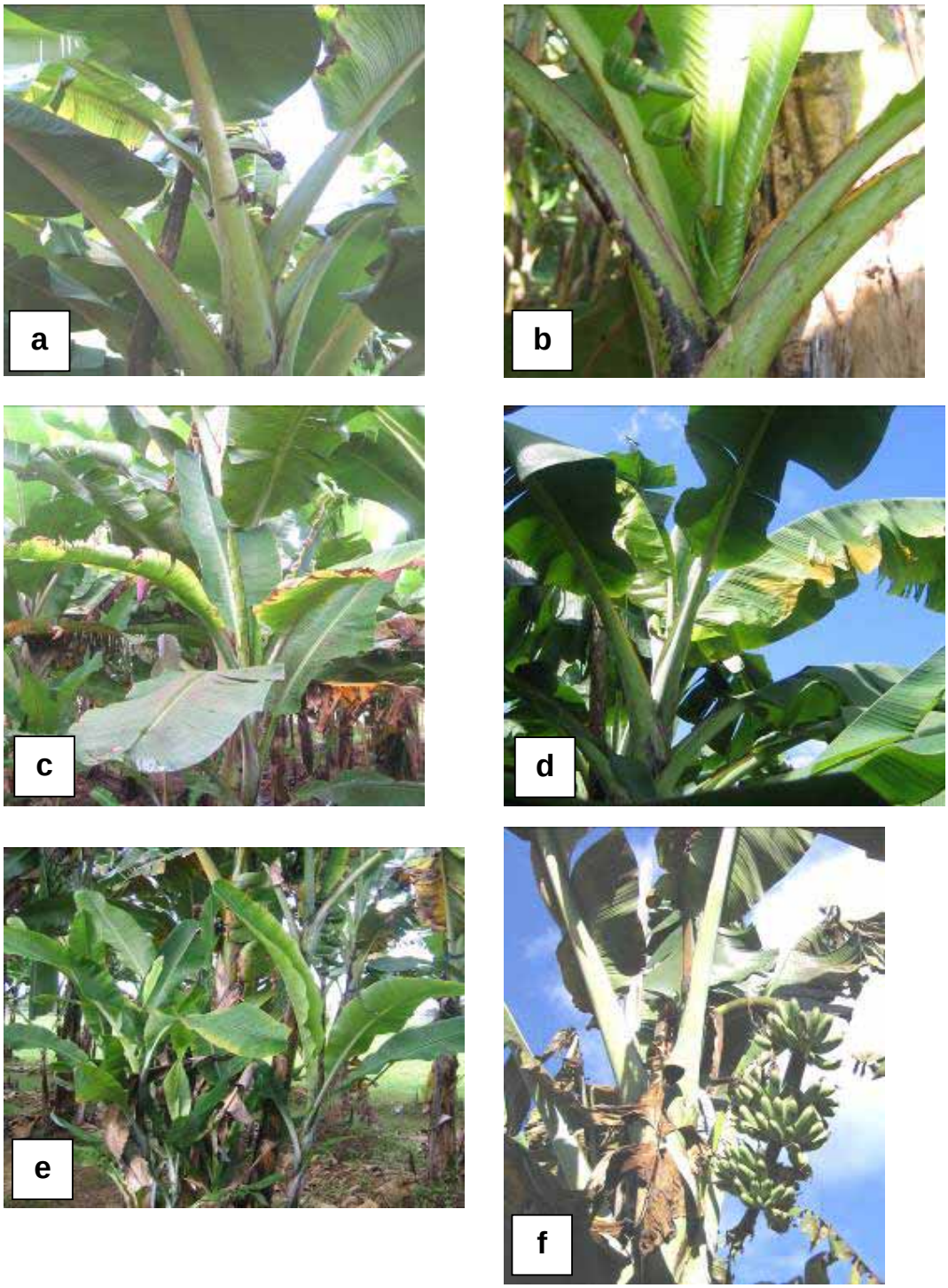


Figure 10. Selected banana cultivars exhibiting symptoms of BBTD
a. FHIA 25
b. FHIA 23
c. Cuarenta dias
d. FHIA 17
e. Lakatan Cavite (suckers)
f. Lakatan Cavite (mother plant)

leaf narrowing, stunting were common to all cultivars. Marginal chlorosis was slight to severe, leaf narrowing, slight, and stunting, slight to severe. In some cultivars, twisting of the leaf blade, curling and distortion specifically the leaf edges were observed. Aside from the common symptoms, necrosis of the leaf margin were noted on some cultivars such as SH 3436-9, SH 3640, GCTCV 119, AACV Rose, FHIA 21 and FHIA 23. Among the local cultivars, necrosis of leaf margins was observed in all cultivars except in Lakatan Mindoro II.

B. Banana bunchy top incidence at CES, Pili Drive, UPLB

Initial rating for BBT incidence was taken from the six introduced and five local banana cultivars planted at Pili Drive, UPLB. Of the local cultivars, Cuarenta Dias had the highest percent incidence (69%) followed by Lakatan Cavite (62%) while Cardaba (7%) had lowest percent incidence followed by Latundan (9%). It was noted that the spread of BBTV was fastest on Lakatan-Cavite. However in Cuarenta Dias, BBT incidence was noted only nine months after planting. BBT incidence on Cardaba was noted only 14 months after planting. On introduced FHIA lines, FHIA 18 had 0% incidence, while FHIA 17 and FHIA 25 had 30% and 33% incidence, respectively (Table 15). The low incidence of BBTD in CES as compared to Mainit, Bay, Laguna was due to the roughing or removal of BBTV-infected plants as the symptoms appeared. FHIA lines, except FHIA 18, and Saba showed symptoms of the disease at flowering stage. In some cultivars, BBTV symptoms were noted on suckers.

C. Role of asymptomatic banana plants on the spread of BBTV

Fifty-five (55) individual suckers from seven local banana cultivars were collected from 16 municipalities of Laguna, Batangas, Quezon and Cavite (Table 16). In all areas, Saba cultivar was collected in almost all locations. At the screenhouse, it was observed that some of the suckers that formed the leaves showed symptoms of the BBTV. Some of the suckers died. Results of ELISA test showed that most of the collected banana cultivars were positive to the virus. Saba cultivar, known to be resistant to BBTV, was observed to be either positive or negative in ELISA test. Although visual manifestation of the symptoms of the disease was not observed, still the virus is present inside the leaf tissues. It is possible that the virus titer was low at the time of collection, then it increased upon incubation. Based on the results, plants showing no symptoms of the disease can be a contributory factor on the rapid and widespread of BBTV in the field.

D. Resistance to *Pentalonia nigronervosa*, the insect vector of BBTV

Ten banana varieties namely: Cardaba. FHIA 1, FHIA 2, FHIA 17, FHIA 21, Lakatan Davao, TMB x 5295-1, CRBP 39, Quarenta Dias and Pisang Ceylan were used to analyze the varietal preference of P. nigronervosa, the aphid vector of BBTV.

It was recorded that in all banana varieties, the peak of aphid reproduction was after 21 days of exposure from the source and beyond that, the population went down.

Table 15. Percent incidence of banana bunchy top on banana cultivars grown in Central Experiment Station, UPLB, College, Laguna

Cultivar	Percent Incidence (at)				
	5 MAP	8 MAP	11 MAP	14 MAP	19MAP
A. Introduced					
FHAI 01	0	0	0	0	7
FHIA 02	0	0	0	0	17
FHIA 17	0	2	7	12	30
FHIA 18	0	0	0	0	0
FHIA 23	0	0	2	2	19
FHIA 25	0	0	2	2	33
B. Local					
Latundan	2	2	2	7	9
Cavendish	2	2	5	10	32
Lakatan-Cavite	5	10	10	24	62
Lakatan-Davao	0	0	2	7	26
Cuarenta Dias	0	0	12	24	69
Cardaba	0	0	0	5	7

MAP – months after planting

Table 16. Reaction of asymptomatic banana cultivars collected from different municipalities of Laguna, Batangas, Quezon and Cavite to ELISA test

Place of Collection	Cultivar	Reaction to ELISA Ab
A. Laguna		
Paciano Rizal, Bay	Bungulan	+
	Cuarenta Dias	
	Plant #1	+
	Plant #2	+
	Lakatan Davao	
	Plant #1	+
	Plant #2	-
	Lakatan Mindoro	
	Plant #1	+
	Plant #2	+
Tranca, Bay	Lakatan	
	Plant #1	+
	Plant #2	-
	Plant #3	+
	Plant #4	+
	Plant #5	+
	Latundan	+
San Antonio, Pila	Turdan/Latundan	-
Duhat, Sta. Cruz	Turdan Puti	+
	Saba	+
Pagsanjan	Lakatan	+
	Latundan	-
San Sebastian, Pasanjan	Saba	-
	Lakatan	+
	Latundan	+
	Bungulan	+
	Cuarenta Dias	+
B. Quezon		
Pandak, Lucban	Saba	
	Plant #1	-
	Plant #2	+
C. Cavite		
Iba, Silang	Saba	-
	Bungulan	+
Tartaria, Silang	Cuarenta Dias	-
Pook, Silang	Saba	+
Mendez, Crossing	Dwarf Cavendish	
	Plant #1	+
	Plant #2	-
	Cuarenta Dias	-
	Latundan	
	Plant #1	-
	Plant #2	+
Tagaytay City	Saba	+
D. Batangas		
Inusluban, Lipa City	Saba	+
San Lucas, Lipa City	Bungulan	+
Dagata, Lipa City	Saba	-
San Fernando, Sto. Tomas	Saba	+

Data revealed that, initially, the most preferred varieties of aphids to colonize were FHIA 21, FHIA 17, CRBP 39, Lakatan Davao and Cardaba as evident by the colony count. The lowest number of aphid was recorded on Pisang Ceylan followed by FHIA 1. After seven and 14 days of exposure, the highest aphid colony count was observed on FHIA 21 followed by FHIA 17.

The peak of aphid reproduction as shown by the highest number of aphid colonies was recorded 21 days after exposure. Lakatan Davao and Quarenta Dias gave the highest number of aphid colonies. The highest rate of reproduction occurred in those varieties indicating that those were most preferred by aphids. It was observed that Pisang Ceylan was the least preferred variety throughout the observation period. It was also interesting to note that cvs. Cardaba and TMB x 5295-1 did not support aphid reproduction throughout the duration of the experiment.

With these observations, further studies must be done to elucidate the mechanism of resistance of the different varieties to the vector.

Resistance to virus multiplication

BBTV infection was recorded from the inoculated test plants of the different varieties. FHIA 2 had the lowest percent infection (6.67%), followed by Pisang Ceylan and Cardaba. Incubation period ranged from 18 to 21 days depending on the variety.

Sub-study 3.2. Evaluation of banana cultivars against nematodes

Activity 3.2.1 Assessment of nematode infection under natural condition

A. Root damage assessment

1. Root damage assessment

Based on egg laying females index, the highest root damage was found on SH 3436-9, AACV Rose, GCTCV-119, and all local cultivars except Cardaba (Table 17). Very few egg masses were found on other cultivars. On root-knot galling index, cultivar Cavendish was the most susceptible to Meloidogyne, having the root-knot galling index of 3. Root-knot galling index on introduced cultivars and other local cultivars was relative low. To determine whether the cultivar is resistant or susceptible based on root knot galling index is not a good evidence since previous studies show the there were instances that swellings do not occur even there is infection of Meloidogyne and large number of egg laying females were found inside the roots.

Percent dead roots was highest on local cultivar Cavendish (32.41%) (Table 18). On introduced cultivars, highest percent dead roots was found on CRBP 30 followed by Gros Michel (17%). Low percentage dead roots was observed on FHIAs which ranged from 0 t0 11.2%. All roots of FHIA 21, TMB X 1378 and Lakatan Cavite were healthy. On percent necrosis, likewise, highest percent was noted on Cavendish (37%). All the local and introduced cultivars had

Table 17. Egg laying females index and root-knot galling of different banana cultivars collected from IPB Demonstration Farm, Brgy. Paciano Rizal, Mainit, Bay, Laguna.

Cultivar	Egg laying females Index	Root–knot galling index
SH 3436-9	2	2
Cachaco	1	1
Pisang Ceylan	1	1
FHIA 18	1	1
AACV Rose	2	1
GCTCV-119	2	2
Cavendish	2	3
Bungulan	2	1
Lakatan Davao	2	2
Cardaba	1	1
Lakatan Mindoro	1*	2
Lakatan Cavite	1*	1
Lakatan Mindoro (Saba)	2*	2

Egg laying females index: 0 – no egg mass, 1 – 1 to 2 egg masses, 2 – 3 to 10 egg masses, 3 – 11 to 30 egg masses, 4 – 31 to 100 egg masses, 5 – more than 100 egg masses.

Root-knot galling index: 1 – very few galls, trace infections, 2 - <25% roots galled, 3 – 25 to 50% roots galled, 4 – 50 to 75% roots galled, 5 - > 75 % roots galled.

Based on 100 g root samples.

*Based on 5 g root samples

Table 18. Percent dead roots and root necrosis of different banana cultivars at IPB Demonstration Farm, Brgy. Paciano Rizal, Mainit, Bay, Laguna

Cultivars	Percent Dead Roots	Percent Root Necrosis[a]
Cavendish	32.4	37.0
CRBP 39	25.7	17.0
Gros Michel	17.0	11.0
TMB X 5295-1	16.7	10.0
GCTCV-119	14.2	25.0
Cachaco	14.0	19.0
Bungulan	12.6	20.0
FHIA 23	11.2	8.0
Pisang Jari Buaya	10.8	6.0
Lakatan MiNdoro	9.8	12.0
Cardaba	9.6	13.0
Lakatan Davao	8.1	15.0
Quarenta Diaz	5.3	11.7
SH 3436-9	4.5	25.0
FHIA 02	4.3	6.7
Pisang Ceylan	4.2	11.0
Yangambi Km5	3.7	25.3
FHIA 17	3.7	16.3
FHIA 01	3.2	15.7
FHIA 18	2.8	13.0
Lakatan Mindoro (Saba)	2.7	9.3
AACV Rose	2.3	16.0
SH 3640	1.8	17.0
Williams	1.5	14.3
FHIA 21	0	11.3
TMB X 1378	0	14.3
Lakatan-Cavite	0	2.3

[a] Based on 5 10-cm root samples.

necrotic roots, which ranged from 2.3 (Lakatan Cavite) to 37% (Cavendish). Since the data were taken from the field, percent dead roots and root necrosis may not only be the result of damage due to nematodes, especially the migratory endoparasites, but the damage may be due to physiological stresses brought about by biological and/or physical factors.

7. Percent Distribution and Nematode Population

There were ten nematode species present in the area where these cultivars were planted (Table 19). Based on percent distribution, *Rotylenchulus* was the most prevalent (21 out of 27 cultivars) followed by *Pratylenchus* (17 out of 21 cultivars). *Rotylenchus*, *Tylenchorrynchus*, *Hemicycliophora* and *Aphelenchoides* were less prevalent. *Radopholus*, *Helicotylenchus* and *Rotylenchulus* were found in all root samples of local (Cardaba, Bungulan, Cavendish) and introduced (SH 3436-9, Cachaco, Pisang Ceylan, FHIA 18, AACV Rose and GCTCV-199) cultivars. On the other hand, *Meloidogyne*, *Pratylenchus*, and *Tylenchorrynchus* were observed on all samples of cultivars Cavendish and GCTCV 119. All root samples of FHIA 18 had *Hoplolaimus* and *Hemicycliophora*, both ectoparasites. *Aphelenchoides*, an ectoparasite was never been reported to be attacking banana. However, in this study, it was found in eight cultivars, namely Lakatan Davao, Lakatan Mindoro, Lakatan Mindoro II, FHIA 01, FHIA 21, CRBP 39, TMB x 1378 and Gros Michel.

On percentage population, *Radopholus* was the most predominant in FHIA 18 (55%), *Helicotylenchus* in Lakatan Davao (84%), *Rotylenchulus* in Williams (92%), *Rotylenchus* in TMB x 1378 (38%), *Meloidogyne* in Lakatan Mindoro (Saba) (47%), *Hoplolaimus* in SH 3640 (82%), and *Tylenchorrynchus* in FHIA 17 (33%) (Table 20). Very low percentage of *Rotylenchus*, *Meloidogyne*, *Hemicycliophora* and *Tylenchorrynchus* was observed on all cultivars. Only *Praylenchus* and *Aphelenchoides* were found on TMB x 5259-1 and FHIA 21, respectively.

8. Nematode Count

Based on nematode count, FHAI 18 had the highest *Radopholus* count (295) followed by Cavendish (177) (Table 21). This nematode was not found in 11 cultivars. PIsang Ceylan had the most number of *Helicotylenchus* (305), while Cachaco had the most number of *Rotylenchulus* (452). Other cultivars had lower counts in most nematode genera observed in the area.

Based on the results obtained, *Radopholus*, *Helicotylenchus* and *Rotylenchulus* were the most prevalent and common genera found infecting local and introduced banana cultivars planted in Mainit, Bay, Laguna. Among the cultivars, 17 were found to be relatively resistant to the ten genera observed.

Activity 3.2.2 Confirmatory screening of banana cultivars for resistance to nematodes under greenhouse condition

Performance of banana cultivars inoculated with *M. incognita* is shown in Table 22. On plant height, Cuarenta Dias had taller plants with inoculation of *M. incognita* than without inoculation. However, in other cultivars, there was a decrease in plant height which ranged from 1.3% as in Latundan to 12.7% as in SH 3436-9. Except of AACV and SH 3646, all cultivars had reduction in pseudostem girth with *M. incognita* inoculation. TMB X 3295-1 had increased shoot weight with *M. incognita* inoculation, where the rest had reduced shoot weight which ranged from 7.2% (Pisang Ceylan) to 40.3% (Lakatan). Among the parameters evaluated, root weight of all the cultivars was affected by the inoculation of *M. incognita*. Cuarenta Dias had the highest percentage reduction (74.1%) followed by Lakatan (57.9%) while TMB X 3295-1 had the lowest (8.9%).

On root galling index, cultivars Lakatan and SH 3646 had the lowest index (1.4) while, Grand Naine, the susceptible check, had the highest (3.5) (Table 23). On the number of juveniles recovered from one gram the inoculated roots, GCTCV 106 had the lowest count (18) followed by AACV Rose (40). Lakatan had the highest nematode count (336) followed by TMB X 3295-1 (334). Based on the result, GCTV 106 was found resistant to M. incognita, while AACV Rose, SH 3646, SH 3436-9 and Cuarenta Dias were moderately resistant.

Response of the five FHIA lines and 4 local cultivars to *Radopholus similis* is shown in Table 24. Based on the results, FHIA 01 had increased plant height, pseudostem girth, shoot and root weight with inoculation of R. similis. On the other hand, other FHIA lines and local cultivars were adversely affected by *R. similis.* FHIA 21 had the highest percent reduction in plant height (35%), pseudostem girth (28.6%) and shoot weight (64.4%). FHIA 23 had the highest reduction in root weight (77.5%).

Among the FHIA lines, FHIA 01 had the lowest percentage dead roots (2.5%), FHIA 18, lowest percentage root necrosis (31.4%) and FHIA 21, the lowest *R. similis* count (593) (Table 25). FHIA 21, although having lower nematode count, had the highest percentage dead roots (70%) and percentage root necrosis (87.2%) than the other local and introduced cultivars tested. The low nematode count obtained could be due to the fact that some of the nematodes may have moved out of the roots due to the lack of healthy tissues. Similar result was found in Grand Naine, the susceptible check. Based on the result on root damage, plant growth parameters and nematode count, FHIA 01 was found resistant to *R. similis.*

Table 19. Percent distribution[a] of nematodes in different banana cultivars based on three samples examined per cultivar

CULTIVAR	NEMATODE GENERA									
	Rado-pholus	*Helico-tylenchus*	*Rotylen-chulus*	*Rotylen-chus*	*Meloido-gyne*	*Pratylen-chus*	*Hoplo-laimus*	*Hemicy cliophora*	*Aphelen-choides*	*Tylenchor-rynhus*
SH 3436-9	100.0	100.0	100.0	0	66.7	0	100.0	0	0	33.3
Cachaco	100.0	100.0	100.0	0	66.7	33.3	0	100.0	0	0
Pisang Ceylan	100.0	100.0	100.0	0	0	66.7	33.3	66.7	0	0
FHIA 18	100.0	100.0	100.0	0	33.3	33.3	100.0	100.0	0	0
AACV Rose	100.0	100.0	100.0	0	66.7	0	0	66.7	0	33.3
GCTCV-119	100.0	100.0	100.0	0	0	100.0	33.3	0	0	0
Cavendish	100.0	100.0	100.0	0	100.0	66.7	66.7	0	0	100.0
Bungulan	100.0	100.0	100.0	0	66.7	0	66.7	33.3	0	0
Cardaba	100.0	100.0	100.0	0	66.7	66.7	66.7	66.7	0	66.7
Lakatan Davao	66.7	100.0	100.0	0	0	66.7	0	66.7	0	0
Yangambi Km5	66.7	0	33.3	0	0	33.3	33.3	0	33.3	0
Pisang Jari Buaya	33.3	0	33.3	33.3	0	33.3	0	0	0	0
SH 3640	33.3	0	66.7	0	0	33.3	33.3	0	0	0
FHIA 02	33.3	0	0	0	0	0	33.3	0	0	0
Lakatan Mindoro	33.3	0	0	33.3	66.7	33.3	33.3	0	66.7	0
Lakatan Mindoro (Saba)	33.3	0	66.7	0	33.3	33.3	0	0	33.3	0
FHIA 01	0	0	33.3	0	0	66.7	0	0	33.3	0
FHIA 17	0	0	0	0	0	0	33.3	0	0	33.3
FHIA 21	0	0	0	0	0	0	0	0	50	0
FHIA 23	0	0	66.7	0	0	33.3	0	0	0	0
CRBP 39	0	0	33.3	0	0	33.3	33.3	0	66.7	0
TMB X 1378	0	0	0	66.7	0	33.3	0	0	33.3	0
TMB X 5295-1	0	0	0	0	0	33.3	0	0	0	0
Williams	0	0	33.3	33.3	0	0	0	0	0	0
Gros Michel	0	0	66.7	0	0	66.7	33.3	0	66.7	0
Lakatan Cavite	0	0	33.3	33.3	33.3	0	0	0	0	0
Quarenta Diaz	0	0	33.3	0	0	0	33.3	0	0	0

[a] Total number of root samples in which each genus was detected divided by the total number of root samples multiplied by 100.

Table 20. Population percentage[a] of nematodes in different banana cultivars based on ten grams root samples per cultivar

CULTIVAR	NEMATODE GENERA									
	Rado-pholus	*Helico-tylenchus*	*Rotylen-chulus*	*Rotyle n-chus*	*Meloido-gyne*	*Pratylen-chus*	*Hoplo-laimus*	*Hemicy cliophora*	*Aphelen-choides*	*Tylenchor-rynhus*
SH 3436-9	12	27	49	0	5	0	7	0	0	0
Cachaco	2	23	72	0	0	0	0	1	0	0
Pisang Ceylan	3	59	36	0	0	0	0	0	0	0
FHIA 18	55	29	13	0	0	0	0	1	0	0
AACV Rose	30	44	13	0	8	0	0	1	0	3
GCTCV-119	35	57	6	0	0	2	0	0	0	0
Cavendish	50	25	22	0	2	1	0	0	0	0
Bungulan	32	41	25	0	1	0	1	0	0	0
Cardaba	7	36	47	0	2	0	1	2	0	2
Lakatan Davao	5	84	9	0	0	0	0	0	0	0
Yangambi Km5	1	0	1	0	0	1	2	0	95	0
Pisang Jari Buaya	2	0	40	9	0	49	0	0	0	0
SH 3640	1	0	16	0	0	1	82	0	0	0
FHIA 02	33	0	0	0	0	0	67	0	0	0
Lakatan Mindoro	2	0	0	2	14	1	7	0	73	0
Lakatan Mindoro (Saba)	18	0	23	0	47	6	0	0	6	0
FHIA 01	0	0	53	0	0	41	0	0	6	0
FHIA 17	0	0	0	0	0	0	67	0	0	33
FHIA 21	0	0	0	0	0	0	0	0	100	0
FHIA 23	0	0	68	0	0	31	0	0	0	0
CRBP 39	0	0	8	0	0	17	8	0	67	0
TMB X 1378	0	0	0	38	0	50	0	0	12	0
TMB X 5295-1	0	0	0	0	0	100	0	0	0	0
Williams	0	0	92	8	0	0	0	0	0	0
Gros Michel	0	0	8	0	0	10	5	0	77	0
Lakatan Cavite	0	0	85	9	6	0	0	0	0	0
Quarenta Diaz	0	0	50	0	0	0	50	0	0	0

[a] Total number of individuals of each genus divided by the total number of all the genera multiplied by 100.

Table 21. Nematode count on different banana cultivars based on ten grams root samples per cultivar

CULTIVAR	NEMATODE GENERA									
	Rado-pholus	*Helico-tylenchus*	*Rotylen-chulus*	*Rotylen-chus*	*Meloido-gyne*	*Pratylen-chus*	*Hoplo-laimus*	*Hemicy cliophora*	*Aphelen-choides*	*Tylenchor-rynhus*
SH 3436-9	14	32	59	0	6	0	8	0	0	0
Cachaco	13	144	452	0	5	2	0	8	0	0
Pisang Ceylan	16	305	188	0	0	1	0	4	0	0
FHIA 18	295	154	72	0	1	2	4	6	0	1
AACV Rose	21	31	9	0	6	0	0	1	0	2
GCTCV-119	67	109	12	0	0	4	0	0	0	0
Cavendish	177	88	77	0	7	5	2	0	0	3
Bungulan	31	40	24	0	1	0	1	0	0	0
Cardaba	12	56	74	0	4	1	3	4	0	3
Lakatan Davao	8	138	14	0	0	1	0	1	0	0
Yangambi Km5	2	0	1	0	0	2	3	0	153	0
Pisang Jari Buaya	1	0	18	4	0	22	0	0	0	0
SH 3640	1	0	18	0	0	1	90	0	0	0
FHIA 02	1	0	0	0	0	0	2	0	0	0
Lakatan Mindoro	2	0	0	2	11	1	6	0	59	0
Lakatan Mindoro (Saba)	3	0	4	0	8	1	0	0	1	0
FHIA 01	0	0	9	0	0	7	0	0	1	0
FHIA 17	0	0	0	0	0	0	2	0	0	1
FHIA 21	0	0	0	0	0	0	0	0	1	0
FHIA 23	0	0	13	0	0	6	0	0	0	0
CRBP 39	0	0	1	0	0	2	1	0	8	0
TMB X 1378	0	0	0	3	0	4	0	0	1	0
TMB X 5295-1	0	0	0	0	0	1	0	0	0	0
Williams	0	0	12	1	0	0	0	0	0	0
Gros Michel	0	0	3	0	0	4	2	0	31	0
Lakatan Cavite	0	0	74	8	5	0	0	0	0	0
Quarenta Diaz	0	0	1	0	0	0	1	0	0	0

Table 22. Comparative performance of local and introduced banana cultivars inoculated with M*eloidogyna incognita* (UPLB isolate)

Cultivar	Plant Height (cm)		Pseudostem Girth (cm)		Shoot Weight (g)		Root Weight (g)	
	Un-inoculated	% Difference	Un-inoculated	% Difference	Un-inoculated	% Difference	Un-inoculated	% Difference
Cuarenta Dias	14.1	+ 29.1	2.2	-4.5	63.7	-15.8	32.0	-74.1
Lakatan	21.8	-10.1	2.1	-23.8	59.8	-40.3	13.3	-57.9
Latundan	30.3	- 1.3	2.3	-8.7	88.1	-19.6	19.9	-55.8
AACV Rose	33.5	-12.5	2.7	+3.6	84.8	-23.0	38.2	-25.6
GCTCV 106	25.4	-7.9	2.2	-9.1	81.9	-23.9	18.5	-15.1
Pisang Ceylan	40.4	-5.9	2.3	-4.3	104.4	-7.2	20.3	-11.7
SH 3436-9	28.4	-12.7	2.5	-12.0	90.6	-23.6	24.3	-23.9
SH 3646	22.3	-6.3	2.1	0	87.0	-22.5	23.1	-39.4
TMB X3295-1	30.6	-4.9	2.2	-27.3	70.1	+2.1	20.1	-8.9
Grand Naine (S)	19.7	-7.6	2.4	-8.3	54.6	-24.2	18.3	-35.5

% Difference = Uninoculated minus Inoculated divided by uninoculated multiplied by 100. + increase, - reduction.

Table 23. Root galling index and reproduction of *Meloidogyne incognita* on different local and introduced banana cultivars

Cultivar	Root Galling Index[a]	Number of juveniles per 1 g root samples
Cuarenta Dias	2.0	63
Lakatan	1.4	336
Latundan	2.1	188
AACV Rose	3.1	40
GCTCV 106	2.2	18
Pisang Ceylan	3.2	118
SH 3436-9	3.1	56
SH 3646	1.4	53
TMB X3295-1	3.4	334
Grand Naine (S)	3.5	105

[a]Root Galling Index: 0 – no galls, 1 – trace to few infections, 2 – <25% of roots galled, 3 – 25-50% of roots galled, 4 – 51 to 75% of roots galled, 5 ->75% of roots galled. S – susceptible check.

Table 24. Comparative response of local and introduced banana cultivars inoculated with *Radopholus similis* (Quezon isolate)

Cultivar	Plant Height (cm)		Pseudostem Girth (cm)		Shoot Weight (g)		Root Weight (g)	
	Un-inoculated	% Difference	Un-inoculated	% Difference	Un-inoculated	% Difference	Un-inoculated	% Difference
Bungulan	30.4	-4.9	2.3	+4.2	81.0	-6.0	17.0	-13.5
Cardaba	30.1	-4.9	2.4	-4.2	103.1	-19.9	33.3	-44.4
Lakatan	25.2	-4.0	3.3	-21.2	113.9	-31.0	40.3	-58.5
FHIA 01	13.8	+2.1	1.5	+2.5	31.9	+23.1	6.6	+12.0
FHIA 02	23.5	-23.0	2.0	+4.8	75.8	-23.1	15.1	-58.3
FHIA 17	27.0	-18.1	2.1	-4.8	85.7	-26.4	22.4	-62.5
FHIA 18	22.2	-10.8	2.0	-9.1	72.4	+1.2	16.9	-13.6
FHIA 21	29.4	-35.0	2.1	-28.6	76.8	-64.4	12.9	-66.7
FHIA 23	28.1	-32.4	2.5	-24.0	111.3	-59.3	21.8	-77.5
FHIA 25	32.1	-17.8	2.7	-25.9	142.2	-50.2	27.5	-76.0
Grand Naine (S)	24.1	-11.6	2.2	-4.5	77.4	-18.7	12.1	-21.5

% Difference = Uninoculated minus – inoculated divided by uninoculated multiplied by 100. + increase, - reduction

Table 25. Root damage assessment and reproduction of *Radopholus similis* (Quezon isolate) on different local and introduced banana cultivars

Cultivar	% Dead Roots	% Root Necrosis	No. of juveniles per 1 g root samples
Bungulan	46.2	72.8	919
Cardaba	21.3	57.0	1,152
Lakatan	33.9	77.8	2,841
FHIA 01	2.5	46.5	809
FHIA 02	28.9	62.4	1,073
FHIA 17	32.2	74.8	2,618
FHIA 18	25.0	31.4	738
FHIA 21	70.0	87.2	598
FHIA 23	46.8	78.7	1,052
FHIA 25	42.8	75.5	1,652
Grand Naine (S)	62.4	85.8	582

S – susceptible check.

Sub-study 3.3. Evaluation of cultivars against sigatoka and other important diseases

Activity 3.3.1 Evaluation of cultivars against Sigatoka leaf spot

Based on youngest leaf spotted (YSL), all of the FHIA lines, FHIA 01, 17, 18, 23 and 25, were resistant to black Sigatoka except FHIA 02 which was susceptible (YLS – 6.2). All the FHIA lines had lower disease severity rating that ranged from 5.5 to 31.4, with corresponding lower index of youngest leaf spotted (11.7 to 24.4) and higher index of non-spotted leaf area (75.6 – 88.3) (Table 26). Response of the six FHIA lines was almost similar.

On the other hand, all the local cultivars evaluated were found to be very susceptible to black Sigatoka. The YSL ranged from 1.0 as in Latundan and Cavendish to 5.6 as in Cuarenta Dias. The disease index and index of YSL likewise where high. Among the local cultivars, it was observed that Cardaba, although it has lower YSL, had lower disease severity index (16.3) and index of YSL (23.3 %). The results obtained were comparable with FHIA 01 and FHIA 02. This could be attributed to the fact that the number of standing leaves at the time of evaluation (harvest) was low (4.7) as compared with all FHIA lines. Cultivars Cavendish and Latundan was found to be very susceptible to black Sigatoka, with the highest index of youngest leaf spotted (100%) suggesting that there was no more leaf area available for photosynthesis to occur. The low number of standing leaves could be due to the presence of many necrotic leaf spots caused by *M. fijiensis*. The two collections of Lakatan, Lakatan-Cavite and Lakatan-Davao, had more or less similar response to *M. fijiensis*.

Activity 3.3.2 Evaluation of cultivars against Fusarium wilt

The affected plants showed symptoms of wilting that consisted of drying of the oldest to the youngest leaves. When the pseudostem was cut, the appearance of purplish discoloration on the pseudostem was noted. There was also foul odor and larvae of corm weevil including tunnels or holes were seen on affected tissues. However, upon isolation of affected tissue on potato dextrose agar plate, growth of Fusarium was noted. The pathogenecity test of the isolate was positive proving that the isolate from the Latundan cultivar was indeed *Fusarium oxysporum* f.*sp. cubense*, the cause of Fusarium wilt in banana.

Sub-study 3.4 Evaluation of banana cultivars for incidence of arthropod pests

Cutworm was the only insect pest observed in the field. Among the varieties planted, only FHIA 01 and FHIA 02 were attacked by the pest. Cutworm fed on the youngest shoot causing about 20 percent damage. Before the shoot could fully emerge, cutworm can almost severe the leaf from the plant.

In the greenhouse, red spider mites and cutworm were observed. There was a very high incidence of spider mites which affected all the cultivars. Application of Acaricide was done. Cutworm was also observed on some plants. Cultivars which were not damaged or infested by the pest were: FHIA 1, FHIA 2, FHIA 18, FHIA 23, CRBP 39, Bungulan, GCTCV 119, Cavendish, Lakatan Cavite, Lakatan Davao and Latundan. Damage caused by cutworm on susceptible cultivars ranged from three to 10 percent.

Table 26. Performance and reaction of local and introduced banana cultivars to black Sigatoka leaf spot (*Mycosphaerella fijiensis* Morelet) taken at harvesting stage.

Cultivar	No. of Standing Leaves	Youngest Leaf Spotted	Disease Severity Index	Index of youngest potted Leaves (%)	Index of Non-spotted (%)	Reaction[a]
Cardaba	4.7	4.6	16.3	23.3	76.7	VS
Cavendish	3.1	1.0	78.3	100.0	0	VS
Cuarenta Dias	8.8	5.6	40.5	48.7	51.3	VS
Lakatan-Cavite	3.1	1.2	65.1	93.8	6.2	VS
Lakatan-Davao	2.8	1.2	66.2	90.3	9.7	VS
Latundan	2.5	1.0	60.9	100.0	0	VS
FHIA 01	9.2	8.7	22.0	16.8	83.2	R
FHIA 02	6.9	6.2	31.4	24.4	75.6	R
FHIA 17	9.5	9.4	10.2	12.1	87.9	R
FHIA 18	9.4	9.3	5.5	15.0	85.0	R
FHIA 23	9.4	9.4	5.5	11.7	88.3	R
FHIA 25	10.6	10.4	10.1	11.9	88.1	HR

[a] Based on youngest leaf spotted (YLS): $\geq$ 10 – highly resistant (HR), 8.5-9..9 – resistant (R), 6.0-8.5 – susceptible (S), < 6.0 – very susceptible (VS).

Sub-project 2. Establishment of a National Repository, Multiplication and Dissemination Center (NRMDC) at the Bureau of Plant Industry - Davao National Crop Research and Development Center (BPI-DNCRDC)

Study 1. Establishment of the National Repository, Multiplication and Dissemination Center (NMRDC)

A total of one hundred eighty five virus-free plants consisting of 30 accessions/cultivars of introduced hybrids, local cultivars (Lakatan and Cardaba) and the Taiwan cultivars (GCTCV 247, 119 and 106) (Table 27) were planted and maintained in clay pots inside insect-proof screenhouses as foundation stocks (Figure 9). These will serve as sources of plant materials for interested farmers/clientele.

Table 27 shows the suckering ability of the plants maintained in clay pots and the field. Data on the production of suckers were done every three months per quarter. AA cv Rose and CRBP-39 produced at least three (3) suckers per quarter compared to FHIA accessions, which produced at least 1 sucker per quarter. FHIA cultivars planted in the field produced 4 – 6 suckers from planting to shooting stage at 21 months.

Observations were done for a period of June 2006 to June 2008.

Figure 11. Improved and superior landraces of banana maintained at the NRMDC, BPI-DNCRDC.

Table 27. List of introduced banana and local cultivars maintained inside the screenhouse as foundation stock

Cultivar	Number of Plants Maintained
FHIA 01	10
FHIA 02	10
FHIA 03	10
FHIA 17	11
FHIA 18	10
FHIA 21	10
FHIA 23	12
FHIA 25	10
GCTCV 119	12
GCTCV 106	10
GCTCV247	10
TMB X 5295-1	2
TMB X1378	2
CRBP-39	2
CACHACO	2
WILLIAMS	10
P. CEYLAN	4
P. JARI BUAYA	4
YANGAMBI-KM 45	10
CV ROSE	2
SH 3436-9	2
CALCUTA	3
EMB 403	4
EMB402	1
EMB 404	2
GRAND NAINE	10
CARDABA	10
LATUNDAN	2
LAKATAN	10

Advantages and Disadvantages of Planting Banana in Clay pots and in the Field

Banana planted in clay pots under screenhouse condition were more manageable in terms of cultural management and control of pests and diseases. More over, time spent and labor cost for maintenance was minimal. Planting in clay pots also required smaller area. However, sucker production was slower and smaller. While in the field, banana grew faster and produced more and larger suckers.

On the contrary, pest and diseases management in the field were more difficult. Labor cost for the maintenance of the area was higher when planted in the field.

Cultural management of plants

Regular pruning was done for all the plants. When plant height reached 180 centimeters, banana plants were pruned 30 centimeters from the base. This was done to maintain a manageable height. Since the start of the study (November 2003), banana collections were pruned four times (4X): on September 2004, October 2005 and January 2007 and January 2008.

Maintenance of Disease free Foundation Stocks

Indexing of test plants

Indexing of test plants by ELISA showed that plants in the repository were all negative to BBTV while in the field (IMTP), some banana accessions were found positive to BBTV (Table 28 and 29). Other diseases such as freckles, Sigatoka, and BSV were also observed in the field. Indexing was done twice a year (2003 to 2008).

Distribution of Improved hybrids, Taiwan and local cultivars

The introduced cultivars and local cultivars (Lakatan and Cardaba) from the repository germplasm were mass-produced through tissue culture (Figure 10) for distribution and research purposes. FHIA hybrids and Taiwan cultivars were distributed to different banana companies (Dole Philippines, Stanfilco, Lapanday and Unifruitti) for their foundation stocks for future disease and agronomic field evaluation.

The cultivars distributed to private companies are resistant to Fusarium wilt.

Table 28. Sucker production of introduced and local banana cultivars planted in clay pots inside the screenhouse and in the field.

Cultivar	SCREENHOUSE			FIELD DEMO From harvest to shooting
	2006	2007	2008	Oct 06 – Jun 08
FHIA 01	0	1	0	4
FHIA 02	1	2	2	4
FHIA 03	1	1	1	4
FHIA 17	1	2	1	5
FHIA 18	0	0	2	4
FHIA 21	0	1	1	6
FHIA 23	1	2	1	4
FHIA 25	2	3	6	0
GCTCV 119	1	2	4	6
GCTCV 106	0	0	2	5
GCTCV247	0	0	2	7
TMB X 5295-1	7	8	6	*
TMB X1378	2	1	2	*
CRBP-39	3	8	13	*
CACHACO	1	3	4	*
WILLIAMS	1	2	3	*
P. CEYLAN	1	2	3	*
P. JARI BUAYA	1	3	3	*
YANGAMBI-KM 45	4	3	3	*
CV ROSE	4	12	16	*
SH 3436-9	1	2	2	*
CALCUTA	0	0	1	*
EMB 403	0	0	1	*
EMB402	0	0	1	*
EMB 404	0	0	0	*
GRAND NAINE	0	0	2	*
CARDABA	0	0	0	6
LATUNDAN	0	1	2	*
LAKATAN	1	1	3	4

0 - no sucker produced
* - not planted in the field

Figure 12. Tissue cultured FHIAs, GCTCV and local varieties (Lakatan and Cardaba) for distribution to different private companies

Table 29. Disease status of improved and superior local banana maintained inside the screenhouses as foundation stocks compared to field established plants.

ITC #	Cultivar	Disease status							
		Greenhouse					Field		
		ELISA					Number of plant infected		
		2003	2004	2005	2008		BBTV	BSV	BBMRV
0504	FHIA 01	-	-	-	-	+	4	0*	0*
0505	FHIA 02	-	-	-	-	+	5	0*	0*
0506	FHIA 03	-	-	-	-	+	6	0*	0*
1264	FHIA 17	-	-	-	-	-	0*	0*	0*
1319	FHIA 18	-	-	-	-	+	1	0*	0*
1332	FHIA 21	-	-	-	-	+	2	0*	0*
1265	FHIA 23	-	-	-	-	+	3	0*	0*
1418	FHIA 25	-	-	-	-	+	10	1	0*
	GCTCV 119	-	-	-	-	-	0*	0*	0*
	GCTCV 106	-	-	-	-	-	0*	0*	0*
	GCTCV247	-	-	-	-	-	0*	0*	0*
1297	TMB X 5295-1	-	-	-	-	-	0*	0*	0*
1296	TMB X1378	-	-	-	-	+	2	0*	0*
1344	CRBP-39	-	-	-	-	-	0*	0*	0*
	CACHACO	-	-	-	-	-	0*	0*	0*
	WILLIAMS	-	-	-	-	+	15	0*	0*
1441	P. CEYLAN	-	-	-	-	+	2	0*	0*
0312	P. JARI BUAYA	-	-	-	-	+	7	0*	0*
1123	YANGAMBI-KM 45	-	-	-	-	-	0*	0*	0*
	CV ROSE	-	-	-	-	-	0*	0*	0*
	SH 3436-9	-	-	-	-	-	0*	0*	0*
	CALCUTA	-	-	-	-	-	0*	0*	0*
	EMB 403	-	-	-	-	-	0*	0*	0*
	EMB402	-	-	-	-	-	0*	0*	0*
	EMB 404	-	-	-	-	-	0*	0*	0*
	GRAND NAINE	-	-	-	-	-	0*	0*	0*
	CARDABA	-	-	-	-	+	3	0*	0*
	LATUNDAN	-	-	-	-	-	0*	0*	0*
	LAKATAN	-	-	-	-	+	6	0*	0*

0* no plant infected
Field * = No. of plants infected

Study 2. Establishment of Field Demonstration Plot

2.1 BPI- DNCRDC

Thirteen cultivars/accessions composed of introduced banana hybrids (FHIA 1, 2, 3, 17, 18, 21, 23 and 25), 2 local cultivars (Lakatan and Cardaba) and three Taiwan cultivars (GCTCV's 119, 247 and 106) were planted in the field demonstration plot (Figure 11). This demonstration plot serves as the showcase of the different improved cultivars to the farmers, researchers and other interested individuals.

Figure 13. Field demonstration plot of introduced and superior varieties of Musa under Davao condition

Pest and Disease status

Banana Bunchy Top Virus (BBTV) was observed in FHIA 2, FHIA 23 and Lakatan at the vegetative stage. Once observed, an infected plant was rouged and replanted. Leaf diseases like Sigatoka and freckle were also observed in all cultivars.

Banana stem borer or the banana pseudostem weevil was observed at fruiting stage. It was first observed in FHIA 23 with 4.76 % infestation followed by FHIA 21 with 30.95% of the total number of plants established.

Agronomic Data

Table 30 shows the introduced banana cultivars and local cultivars planted in the field. It was observed that the earliest to shoot was FHIA 2 (236 days) followed by FHIA 01 and FHIA 18 with 328 and 333 days, respectively; this was comparable to the local cultivar Lakatan. The last to shoot was the local cultivar Cardaba, with an average of 398 days.

Table 30. Agronomic Data of Banana accessions at shooting stage

Cultivar	Days from planting to shooting	Height at shooting	Height of the follower at shooting	No. of Functional leaves
FHIA 1	328	265.24	130.6	14
FHIA 2	236	227.33	111.32	14
FHIA 3	364	258.02	122.30	13
FHIA 17	379	280.83	123.59	12
FHIA 18	333	233.50	115.54	13
FHIA 21	364	262.95	97.81	9
FHIA 23	366	283.52	151.51	12
Lakatan	327	293.27	97.22	11
Cardaba	398	377.60	156.72	12

n = 3 replicates

Among the introduced cultivars, it was observed that FHIA 23 was the tallest with an average height of 280.8 cm. Cardaba had an average height of 377.6 cm at shooting, which was taller than the introduced cultivars. Functional leaves of all cultivars ranged from 9-14. All FHIA hybrids produced more functional leaves than the local cultivars, except FHIA 21.

The highest pseudostem girth was observed in Cardaba with an average size of 76.4 cm. This is comparable to FHIA 23 with an average pseudostem girth of 70.7 cm. The smallest girth was observed in FHIA 21 (46.3 cm) and FHIA 2 (47.5 cm). At harvest, there was low incidence of sigatoka, as evidenced by the high number of functional leaves.

Table 31 shows that the earliest to be harvested was FHIA 2 (369 days) and the last was FHIA 3 (489 days).

Table 31. Agronomic data of banana accessions at harvest stage

Accession	Days from planting to harvesting	Average girth of pseudostem at harvest	No. of Functional leaves at harvest
FHIA 1	481	59.62	5
FHIA 2	369	47.20	7
FHIA 3	489	59.96	7
FHIA 17	465	64.84	7
FHIA 18	420	51.16	4
FHIA 21	396.	46.39	4
FHIA 23	487	70.75	6
Lakatan	417	51.56	4
Cardaba	447	76.49	4

The highest average yield was observed in FHIA 17 (27.4 kg) followed by FHIA 23, FHIA 1 and FHIA 3 with yields of 25.6 kg, 25.0 and 20.1kg, respectively (Table 32). Cardaba produced yield of 23.32 kg, comparable to the introduced cultivars.

In terms of the number of hands, FHIA 17 and FHIA 23 produced the same number of hands. However, FHIA 23 had the highest number of fruits in a bunch with 197. FHIA 01 produced the heaviest finger (162.4 g) and the lightest was observed on FHIA 18 (116.3 g). However, fruit weight obtained in FHIA 18 was heavier compared to cultivar Lakatan, with fruit weight of 110.1 g.

Table 32. Yield performance of ten banana accessions planted at the field demo trial at BPI-Davao, Philippines

Cultivar	Ave. bunch weight (kg)	Ave. number of hands in a bunch	Ave. number of fruits in a bunch	Ave. fruit weight (g)
FHIA 1	25.01	9	140	162.42
FHIA 2	17.44	9	113	148.25
FHIA 3	20.18	9	146	129.08
FHIA 17	27.41	12	184	143.22
FHIA 18	16.63	9	132	116.39
FHIA 21	12.82	7	90	130.02
FHIA 23	25.63	12	197	128.95
LAKATAN	18.54	7	119	110.19
CARDABA	23.32	7	144	143.44

2.2 Bukidnon

Reaction to Diseases

Regular disease monitoring revealed that banana bunchy top disease was prevalent in the area near the experimental site. This can be traced to the farmer's use of banana seed-pieces possibly from infected mother plants as planting materials for his Lakatan crop in the adjacent lot. Although the farmer managed the spread of the disease through regular eradication of infected plants, three (3) months after planting, a few test plants were exhibiting initial symptoms of banana bunchy top in the experimental area. Four (4) months after planting, plants exhibited typical symptoms of banana bunchy top disease which were immediately eradicated. Eighteen (18) months after planting, a total of twenty-seven (27) plants were eradicated due to bunchy top virus and fusarium wilt (Table 33).

Table 33. List of eradicated test plants in the field test in Bukidnon due to diseases.

Cultivar	Percent Incidence	
	Fusarium wilt	Bunchy Top Virus
FHIA 03	0	3.33
FHIA 18	26.66	23.33
FHIA 21	0	6.66
Cardaba	6.66	13.33
Lakatan	0	10.00

In terms of average number of functional leaves (FL) at shooting, FHIA 03 (cooking-type) had the highest number, with 14 leaves having more than 50% green area while FHIA 18 (dessert type)had 13 functional leaves.

At harvest, the number of functional leaves was very high in FHIA 03 with 10 functional leaves (Table 34). This indicates that the accession is resistant to sigatoka under Bukidnon condition.

Table 34. Agronomic data at shooting stage from banana plants planted at Bukidnon field trial.

Cultivar	Ave. days from planting to shooting	Ave. number of functional leaves at shooting
FHIA 03	344.00	14
FHIA 18	324.43	13
FHIA 21	377.74	12
FHIA 23	374.18	12
LAKATAN	352.00	8
CARDABA*	*	*

*no data was gathered

FHIA 18 was the earliest to flower at 324 days among the dessert type and FHIA 03 at 344 days for the cooking type.

Harvest data showed that among the cooking types, FHIA 03 was the earliest to mature at 400 days from planting, and FHIA 18 matured at 406 days from planting among the dessert types (Table 35).

Table 35. Agronomic data of selected banana varieties at harvest from the Bukidnon field trial.

Cultivar	Ave. time from planting to harvest (d)	Ave. height of pseudostem at harvest (cm)	Ave. girth of pseudostem at 1m above ground level at harvest (cm)	Ave. height of following sucker at harvest (cm)	Ave. number of functional leaves at harvest
FHIA 03	400	315.17	67.88	198.66	10
FHIA 18	406	253.57	50.08	224.44	5
FHIA 21	444	370.67	65.48	206.40	5
FHIA 23	463	307.32	75.66	136.73	6
LAKATAN	425	338.70	56.28	147.26	0.4
CARDABA	611	452.97	88.48	436.55	5

Table 36 shows the yield data of the test plants. It can be observed that the cooking hybrids, FHIA 03 and FHIA 21, were superior than the local cooking cultivar Cardaba in terms of finger weight and finger length. FHIA 03 and FHIA 21 had finger weights of 150 g and 162.3 g, respectively, compared to Cardaba with 124.9 kg. For finger length, FHIA 03 and FHIA 21 had 17.5 cm and 24.1 cm respectively, compared to Cardaba with 15.8 cm.

Table 36. Performance yield data from Bukidnon field trial.

Cultivar	Ave. Bunch weight (kg)	Ave. Number of Hands	Ave. Number of fruits	Ave. Fruit weight (g)	Ave. Finger length (cm)	Ave. Finger girth (cm)
FHIA 03	26.58	9	154	150.00	17.55	14.26
FHIA 18	17.39	8	125	121.65	18.45	12.41
FHIA 21	22.26	8	123	162.31	24.19	12.48
FHIA 23	27.36	14	228	94.09	17.52	11.02
LAKATAN	16.71	7	124	111.26	17.88	11.11
CARDABA	26.62	11	191	124.98	15.86	15.78

Dessert hybrids FHIA 18 and FHIA 23 on the other hand, were far more superior than the local dessert cultivar Lakatan in terms of yield characteristics (bunch weight, finger weight, number of hands and number of fingers).

Post harvest quality of fruits

Postharvest quality of fruits harvested was evaluated in terms of its general appearance, firmness, peduncle strength, post-harvest characteristics, resistance to diseases, yield, and taste (Table 37).

Table 37. Post harvest quality of banana and plantain cultivars planted in Bukidnon

Desired Characteristics	Cooking variety	Dessert variety
General appearance	FHIA 03 (good)	FHIA 18 (good) FHIA 23 (good)
Firmness	FHIA 03 (firm)	-
Peduncle strength	FHIA 21 (very good)	FHIA 18 (good)
Yield	FHIA 03, FHIA 21	FHIA 23
Long shelf life		FHIA 23
Resistance to diseases	FHIA 21	
Taste and acceptability	FHIA 21	FHIA 18

Study 3. Evaluation for pests and diseases

Activity 3.1 Evaluation for resistance to Fusarium wilt

Reaction to Disease

Fusarium wilt was observed in different accessions three to fifteen months after planting in the field (Table 38). External symptoms such as yellowing of the older leaves which progressed to the younger leaves, wilting of the plant, splitting of the pseudostem and petiole buckling were observed. Internal symptoms were also observed on the vascular tissues of the corm, pseudostem and in the petioles of Williams, FHIA 18 and Latundan only.

The highest percentage infection was observed on the local cultivar Latundan at 55 % followed by FHIA 17 and FHIA 18 with 25 % infection. Low incidence was observed in Williams, Pisang Jari Buaya, FHIA 23, CRBP 39 and Pisang Ceylan with only 10 percent (Table 39).

At the end of the first cropping season, FHIA 02, FHIA 03, FHIA 21, FHIA 25 ,AA cv Rose, Yangambi Km 5, TMB x 1378, TMB x 5295-1, TMB 3x 15-108-6 , SH3436-9 and SH3640 were found to be resistant to Fusarium wilt.

Table 38. Cultivars observed to be infected with Fusarium wilt at different time intervals.

3 months	7 months	8-15 months
FHIA 17	Williams	Pisang Jari Buaya
FHIA 23	Gros Michel	CRBP 39
	FHIA 18	Pisang Ceylan
	Latundan	Cachaco

Table 39. Percent disease incidence of banana plants evaluated against Fusarium at BPI-Davao

Cultivar	Percent Infection (%)
Wiiliams	10
Cachaco	12.5
Jari Buaya	10
FHIA 02	0
FHIA 03	0
Aacv Rose	0
Gros Michel	15
Yangambi Km 5	0
FHIA 17	25
FHIA 23	10
SH 3436-9	0
TMBx 1378	0
TMBx 5295-1	0
SH 3640	0
FHIA 18	25
FHIA 21	0
CRBP 39	10
TMB 3x 15108-6	0
FHIA 25	0
Pisang Ceylan	10
Latundan	55

Agronomic data

Table 40 shows the agronomic data of the different cultivars in the field at shooting stage. The earliest to shoot was AA cv Rose which had an average of 249 days, followed by Pisang Ceylan (263 days). Yangambi Km 5 was the last to shoot at 365 days.

TMB x 1378 was the tallest at 348 cm at shooting. Williams was the shortest, which was 155.6 cm high at shooting.

Average number of functional leaves at shooting ranged from nine (9) to fifteen (15). All of the accessions produced suckers which ranged from 109.5 to 269.7 cm high.

Table 41 shows the agronomic characteristics of the different cultivars at harvest. The average number of days to harvest ranged from 355 to 497. Pisang Ceylan was the earliest to be harvested while FHIA 23 was the last to be harvested. The average number of leaves at harvest ranged from 1-8 leaves with pseudostem girth ranging from 27.6 - 80 cm.

Table 40. Agronomic data of twenty-one (21) banana accessions planted at BPI-DNCRDC for Fusarium evaluation at shooting stage.

ITC #	Cultivar	Ave. time from planting to shooting (d)	Ave. number of leaves at shooting	Ave. plant height at shooting (cm)	Ave. Sucker height at shooting (cm)
0312	P. Jari Buaya	344.8	12	302.0	261.8
0505	FHIA 02	343.3	12	223.3	132.8
0506	FHIA 03	320.3	14	255.2	161.9
0570	Williams	293.4	12	155.6	109.5
0643	Cachaco	345.1	12	319.0	162.4
0712	Aacv Rose	249.6	12	177.1	182.5
1122	Gros Michel	385.6	10	336.0	250.4
1123	Yangambi Km 5	726.6	9	395.4	303.6
1264	FHIA 17	394.6	13	68.2	189.1
1265	FHIA 23	430.9	10	292.4	130.2
1283	SH3436-9	543.6	9	319.6	148.7
1296	TMBx 1378	358.8	11	348.0	262.7
1297	TMBx 5295	342.4	13	277.9	117.8
1307	SH3640	274	14	237.6	152.4
1319	FHIA 18	288.8	13	230.7	153.2
1332	FHIA 21	370.5	11	308.9	184.1
1344	CRBP 39	398.4	12	303.8	141.1
1417	TMB3 x15-108-6	335.5	13	269.9	183.6
1418	FHIA 25	397.3	15	295.0	184.2
1441	Pisang Ceylan	263.7	13	263.7	269.7
	LATUNDAN	358.4	10	315.4	240.8

Table 41. Agronomic data of twenty-one (21) banana accessions planted at BPI-DNCRDC for Fusarium evaluation at harvest.

ITC #	Cultivar	Average number of days to harvest (d)	Average number of leaves at harvest	Average pseudostem girth (cm)
0312	P. Jari Buaya	427.6	4	37.7
0505	FHIA 02	444.8	7	45.5
0506	FHIA 03	403.2	6	63.9
0570	Williams	380.8	3	44.2
0643	Cachaco	422.4	5	47.8
0712	AA cv Rose	360.3	7	27.6
1122	Gros Michel	454.9	2	58.3
1123	Yangambi Km 5	395.4	4	63.3
1264	FHIA 17	461.6	6	68.2
1265	FHIA 23	497.0	4	74.1
1283	SH3436-9	652.3	4	74.2
1296	TMBx 1378	445.0	4	67.6
1297	TMBx 5295-1	424.9	5	49.7
1307	SH3640	366.9	7	50.0
1319	FHIA 18	388.0	4	49.2
1332	FHIA 21	446.8	2	56.1
1344	CRBP 39	490.5	6	51.8
1417	TMB3 x 15-108-6	427.1	4	59.7
1418	FHIA 25	482.5	8	80.0
1441	Pisang Ceylan	355.2	7	53.9
	LATUNDAN	402.8	1	53.6

Table 42 shows the yield performance of different accessions that were evaluated in the field. Among the FHIA accessions, the heaviest bunch weight was 41.3 kg (FHIA 25) followed by FHIA 03 (23.8 kgs). FHIA 17 had bunch weight of 30.1 kg while AA cv Rose had the smallest average bunch weight of only 5.87 kilograms. FHIA 23 and 25 both produced 14 hands in a bunch. P. Jari Buaya, FHIA 02, and the local cultivar Latundan had comparable average bunch weight, which were 10.14 kg, 10.10 kg and 10.9 kg, respectively.

Table 42. Yield performance at harvest of twenty-one (21) banana accessions planted at BPI-DNCRDC for Fusarium evaluation

ITC #	Cultivar	Average Bunch Weight (Kg)	Average Number of Hands	Average Number of Fruits
0312	P. Jari Buaya	10.14	8	131
0505	FHIA 02	10.10	7	92.3
0506	FHIA 03	23.8	9	150.7
0570	Williams	13.8	8	130.5
0643	Cachaco	9.1	5	54.1
0712	Aacv Rose	5.87	10	119.5
1122	Gros Michel	15.6	8	116.6
1123	Yangambi Km 5	6.4	7	139.8
1264	FHIA 17	30.1	11	180
1265	FHIA 23	20.4	14	235.9
1283	SH 3436-9	18.0	9	145.7
1296	TMBx 1378	19.2	8	119.2
1297	TMBx 5295-1	16.4	7	84.2
1307	SH3640	18.2	8	101.2
1319	FHIA 18	12.0	8	116.5
1332	FHIA 21	20.7	7	100.5
1344	CRBP 39	15.0	6	78.4
1417	TMB3 x15-108-6	20.5	8	139.5
1418	FHIA 25	41.3	14	269.9
1441	Pisang Ceylan	20.8	11	189.9
	LATUNDAN	10.9	8	105.6

FHIA 25 produced the highest number of fruits in a bunch, which was 269.9 fruits followed by FHIA 23 and Pisang Ceylan with 235.9 and 189.9 fruits, respectively. The lowest yield was observed in Cachaco.

Monitoring of Planting Materials Distributed to Commercial Plantations

Three cultivars identified resistant to fusarium wilt were distributed to different commercial plantations and for the Demo Plot of BPI-DNCRDC at Bago Oshiro, Davao City. The plantlets were already established in the field and at present no incidence of Fusarium wilt has been observed from vegetative stage up to the fruiting stage.

One of the recipient plantations was visited to observe the performance of GCTCV 119. The plants were planted in a Fusarium wilt-infected farm but they were already on their fruiting stage (Figure 14) and yet there was no incidence of Fusarium wilt disease. The adjacent area planted to Cavendish was observed to be severely infected with Fusarium wilt as early as the vegetative stage.

Figure 14. GCTCV 119 at fruiting stage

Activity 3.2 Sigatoka

Disease Development Time (DDT)

Among the fourteen (14) introduced accessions (Table 43), P. Jari Buaya was the earliest to develop ten (10) lesions with an average DDT of 77.1 days. For the local susceptible check Lakatan, DDT was at 84.8 days. Among the FHIA'S, FHIA 03 had the lowest DDT at 90. 8 days followed by FHIA 21, FHIA 02 and FHIA 18 with an average DDT of 96.2, 97.5 and 102.2 days respectively. FHIA 01 had the longest DDT at 130.6 among the introduced hybrids. DDT observed for FHIA 01 was much longer than Cardaba, the local resistant check with DDT of 109.8 days.

Table 43. Disease development time of *Musa* accessions evaluated against Sigatoka at BPI-Davao.

ITC #	Cultivar	Disease Development Time (Number of days)
0506	FHIA 03	91
1319	FHIA 18	103
0504	FHIA 01	131
1332	FHIA 21	97
1418	FHIA 25	106
0505	FHIA 02	98
1344	CRBP-39	100
1123	YANGAMBI Km 5	112
1907	SH-3640	93
1297	TMB X 5295 – 1	105
1296	TMB X 1378	104
1441	P. Ceylan	116
1417	TMB X 15108-6	103
0312	P. Jari Buaya	78
Local	Lakatan	85
Local	Cardaba	110

Youngest Leaf Spotted (YLS)

Lowest youngest leaf spotted (YLS) was observed in FHIA 02 at leaf number 9, which is the same as that of Lakatan, the local susceptible check. For FHIA's 18, 01, 25 and 03, YLS was observed at leaf number 11 to 14 which was comparable to Cardaba, the local resistant check (Table 44).

Table 44. Youngest leaf spotted of *Musa* accessions evaluated against Sigatoka at BPI-Davao.

ITC #	Cultivar	Average Youngest leaf spotted
0506	FHIA 03	11
1319	FHIA 18	13
0504	FHIA 01	14
1332	FHIA 21	10
1418	FHIA 25	11
0505	FHIA 02	9
1344	CRBP-39	10
1123	YANGAMBI Km 5	9
1907	SH-3640	10
1297	TMB X 5295 – 1	10
1296	TMB X 1378	11
1441	P. Ceylan	11
1417	TMB X 15108-6	11
0312	P. Jari Buaya	9
Local	Lakatan	9
Local	Cardaba	11

At six (6) months, disease severity was higher on Lakatan (32.5) followed by SH 3640 (29.8). FHIA 08, 01, 21 and 02 had the lowest disease severity, at 10.3 and 16.2 for FHIA 03 and FHIA 25, respectively. Cardaba, the local resistant check had the lowest among the entries evaluated with a disease severity rating of 0.9 (Table 45).

At bunch emergence there was an increase of infection index in all introduced hybrids. However, all FHIA cultivars and other hybrids still had a low Disease Severity (DS) ranging from 19.2 to 42.35 compared to Lakatan with a DS of 60 .37. Cardaba, had a low DS of 14.50.

At harvest, disease severity also increased with infection index ranging from 42.14 to 94.04. FHIA cultivars still had a lower DS compared to Lakatan with a DS of 95.90 and to Pisang Jari Buaya with DS of 94.04 followed by SH 3640 with a DS of 82.91. Yangambi Km 5 had the lowest with a DS of 16.67, which was comparable to Cardaba with a DS of 20.70.

Table 45. Disease severity at 6 months, shooting and harvest of Musa accessions evaluated against sigatoka at BPI-Davao.

ITC #	Cultivar	Disease Severity		
		6 mos	At shooting	At harvest
0506	FHIA 03	10.8	35.32	47.14
1319	FHIA 18	5.8	23.58	42.14
0504	FHIA 01	4.3	19.12	43.55
1332	FHIA 21	5.8	32.23	53.47
1418	FHIA 25	16.2	29.60	50.28
0505	FHIA 02	9.2	23.36	49.08
1344	CRBP-39	15.9	37.13	67.60
1123	YANGAMBI Km 5		2.08	16.67
1907	SH-3640	29.8	42.35	82.91
1297	TMB X 5295 – 1	10.8	31.67	58.90
1296	TMB X 1378	16.6	25.00	54.51
1441	P. Ceylan	17.6	32.74	65.43
1417	TMB X 15108-6	19.5	34.77	68.00
0312	P. Jari Buaya	18.4	51.64	94.04
Local	Lakatan	32.5	60.37	95.03
Local	Cardaba	0.9	14.50	20.70

Agronomic evaluation

Agronomic data at shooting

Table 46 shows that among the FHIA cultivars, the last to shoot was FHIA 25 (449 days), and followed by FHIA 03 (368 days). The earliest to shoot was FHIA 01, with an average of 355 days.

For the other introduced cultivars, Yangambi Km 5 was the last to shoot at 726 days followed by Pisang Jari Buaya at 401 days; SH 3640 was the earliest to shoot at 316 days. In the local cultivars, Cardaba was the last to shoot at 455 days.

In terms of height, the shortest was FHIA 02 with only 227 cm, followed by FHIA 18 at 234 cm. FHIA 25 was the tallest at 292 cm. Compared to others cultivars, TMB X 5295-1 was the tallest at 318 cm, the local cultivar Cardaba was the tallest at 320 cm.

Table 46. Agronomic data at shooting of sixteen (16) banana accessions planted at BPI-Davao for Sigatoka evaluation .

ITC #	Cultivar	Ave. time of Planting to shooting	Ave. plant height at shooting	Ave. plant height of the follower/ sucker at shooting	Number of functional leaves at Shooting
0506	FHIA 03	368	271	124	15
1319	FHIA 18	360	234	135	14
0504	FHIA 01	355	242	137	16
1332	FHIA 21	392	276	118	13
1418	FHIA 25	449	292	135	15
0505	FHIA 02	366	227	109	14
1344	CRBP-39	383	283	110	17
1123	YANGAMBI Km 5	726	258	236	11
1907	SH-3640	316	247	147	16
1297	TMB X 5295 – 1	365	254	113	12
1296	TMB X 1378	383	318	185	14
1441	P. Ceylan	339	278	141	14
1417	TMB X 15108-6	364	255	149	14
0312	P. Jari Buaya	401	258	108	10
Local	Lakatan	383	275	130	9
Local	Cardaba	456	320	183	12

Harvest data

Out of the 16 accessions, SH 3640 was the earliest bunch to mature at 412 days from planting to harvest, followed by Pisang Ceylan at 415 days. The latest to mature was Yangambi Km 5 at 803 days. Among the FHIA accessions, FHIA 03 was the earliest to mature and FHIA 25 was the latest at an average of 450 and 556 days, respectively. Among the accessions, Cardaba was the last to mature at 578 days (Table 47).

The less number of functional leaves was observed in Pisang Jari Buaya and Lakatan with an average of 3 leaves which are susceptible to sigatoka. FHIA cultivars were observed to have more functional leaves at harvest, ranging from 6-9. This is an indication that these introduced accessions were resistant and tolerant to sigatoka .

Table 47. Agronomic data at harvest of sixteen (16) banana accession planted at BPI-Davao for Sigatoka evaluation.

ITC #	Cultivar	Time of Planting to harvest	Girth of pseudostem at harvest	Number of functional leaves at harvest
0506	FHIA 03	450	62	8
1319	FHIA 18	455	53	8
0504	FHIA 01	457	48	6
1332	FHIA 21	470	58	6
1418	FHIA 25	556	75	9
0505	FHIA 02	480	44	8
1344	CRBP-39	460	49	7
1123	YANGAMBI Km 5	803	48	5
1907	SH-3640	412	52	6
1297	TMB X 5295 – 1	452	48	6
1296	TMB X 1378	471	70	7
1441	P. Ceylan	415	61	8
1417	TMB X 15108-6	454	57	4
0312	P. Jari Buaya	514	56	3
Local	Lakatan	451	48	3
Local	Cardaba	578	68	6

Yield Performance

Table 48 shows that FHIA 25 obtained the highest yield, with an average bunch weight of 31 kg, followed by FHIA 03 and FHIA 01, with an average bunch weight of 19 kg and 18 kg respectively. The lowest yield was obtained in Yangambi Km-5, CRBP -39 and P. Jari Buaya. The local accessions (Lakatan and Cardaba) showed good yield performance of 12 and 13 kg bunch weight respectively.

Accessions FHIA 03, 18 and 01, SH 3640 and TMB x 1378 have the same average number of hands in a bunch with 8, while FHIA 25 had the highest average number with 13 hands.

In terms of number of fruits in a bunch, FHIA 25 has the highest average number of fruits with 230 fruits followed by Pisang Ceylan with an average of 181 fruits. CRBP-39 has the smallest average number of 66 fruits in a bunch.

Based on the results of the disease development time (DDT), youngest leaf spotted (YLS) and disease severity at 6 months, shooting and harvest, the FHIA hybrids can be considered resistant to sigatoka disease although FHIA 02 has a YLS of number 9 leaves. However, Yangambi Km 5 and Cardaba are highly resistant among all sixteen accessions.

Lakatan has the highest DS from 6 months to harvest. Among the FHIA cultivars, disease severity was almost the same except for FHIA -01 which recorded the lowest infection index from 6 months to harvest.

Table 48. Yield performance of sixteen (16) banana accessions planted at BPI-Davao for Sigatoka evaluation taken at harvest.

ITC #	Cultivar	Bunch weight (Kg)	Number of hands	Fruit in a bunch	Fruit weight (g)
0506	FHIA 03	19	8	133	143
1319	FHIA 18	13	8	111	90
0504	FHIA 01	18	8	111	150
1332	FHIA 21	16	7	107	131
1418	FHIA 25	31	13	230	130
0505	FHIA 02	13	9	123	100
1344	CRBP-39	9	6	66	105
1123	YANGAMBI Km 5	7	6	73	75
1907	SH-3640	17	8	98	148
1297	TMB X 5295 – 1	11	6	67	149
1296	TMB X 1378	16	8	141	189
1441	P. Ceylan	16	10	181	84
1417	TMB X 15108-6	14	7	129	88
0312	P. Jari Buaya	8	7	89	70
Local	Lakatan	13	7	103	79
Local	Cardaba	12	7	111	99

Comparison of average agronomic data

Results on agronomic data of the same banana accessions used in field trial at BPI-Davao, Bukidnon, IMTP on Fusarium and Sigatoka showed that at shooting stage, it was observed that the earliest average time from planting to shooting was recorded from Fusarium trial than in Bukidnon and Sigatoka trial. On the average, number of functional leaves from three sites does not differ greatly (Table 49).

At harvest it was observed that FHIA cultivars used in the Bukidnon trial, FHIA 03 were the earliest to harvest at 400 days followed by FHIA 18 at 406 days. The last to harvest was observed in the local cultivars the Cardaba which is 611 days. (Table 50)

For the yield performance of the same cultivars used in the four (4) trials, higher yield was obtained from Bukidnon trial (Table 51). Since the area is considered a highland the climate condition of the area is favorable for the growth and development of the introduced hybrids.

Table 49. Comparison of average agronomic data at shooting stage of different banana accessions gathered from field trial BPI- Davao and Bukidnon, IMTP on Fusarium and Sigatoka

Trials site	Average time from planting to shooting (d)						Average number of functional leaves at shooting (d)					
	FHIA 03	FHIA 18	FHIA 21	FHIA 23	Lak	Car	FHIA 03	FHIA 18	FHIA 21	FHIA 23	Lak	Car
BPI-Davao	364	333	364	366	327	398	14	13	9	12	11	12
Bukidnon	344	235	378	375	352	-	14	13	12	12	8	
Fusarium	321	289	371	431		-	14	13	11	10	-	-
Sigatoka	368	360	392		383	456	15	14	13	-	9	12

- no data gathered

Table 50. Comparison of average yield performance of different banana accessions gathered from field trial BPI-Davao and Bukidnon, and IMTP on Fusarium and Sigatoka.

Trials site	Average time from planting to Harvest (d)						Average girth of pseudostem at 1 m above ground level at harvest (cm)						Average number of functional leaves at harvest					
	FHIA 03	FHIA 18	FHIA 21	FHIA 23	Lak	Car	FHIA 03	FHIA 18	FHIA 21	FHIA 23	Lak	Car	FHIA 03	FHIA 18	FHIA 21	FHIA 23	Lak	Car
BPI-Davao	489	420	397	486	417	448	59.96	51.16	46.39	76.75	51.56	76.49	7	4	6	4		4
Bukidnon	400	406	444	463	425	611	67.88	50.08	65.48	75.66	56.28	88.48	10	5	5	6	0.4	5
Fusarium	404	388	447	97	-	-	67.9	49.2	56.1	74.1	-	-		4	5	4	-	-
Sigatoka	450	455	470	-	451	510		53	8	-	48	68	8	8	6	-	3	6

Table 51. Comparison of average yield performance at harvest of different banana accessions gathered from field trial in BPI Davao and Bukidnon, and IMTP on Fusarium and Sigatoka.

TRIAL SITES	Average Bunch weight (kg)						Average number of hands						Average number of fruits						Average Fruit weight					
	FHIAs				Lak	Car	FHIAs				Lak	Car	FHIAs				Lak	Car	FHIAs				Lak	Car
	01	18	21	23			01	18	21	23			01	18	21	23			01	18	21	23		
BPI-Davao	21	17	13	26	19	23	9	9	7	12	7	9	146	132	90	197	119	144	130	117	131	129	111	144
BUKIDNON	27	18	23	28	17	27	9	8	8	14	-	-	154	125	123	118	124	91	150	-	163	95	112	125
FUSARIUM	24	12	21	21	-	-	9	8	7	14	-	-	151	117	100	236	-	-	-	-	-	-	-	-
SIGATOKA	19	13	16		3	12	8	8	7		7	7	133	111	107	-	103	111	143	90	131	-	79	99

6. OTHER ACCOMPLISHMENTS

Publications

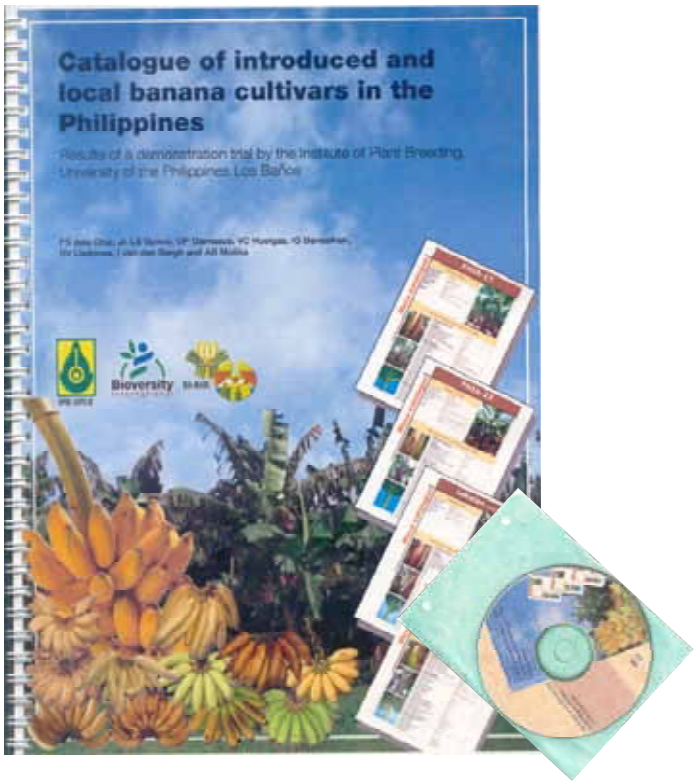
Manuscript published

1. Agronomic and yield performance of introduced and popular local banana cultivars (*Musa* spp.) in the Philippines *(Published in the Phil. Jour. Crop Sci 34(1): 88-98)*

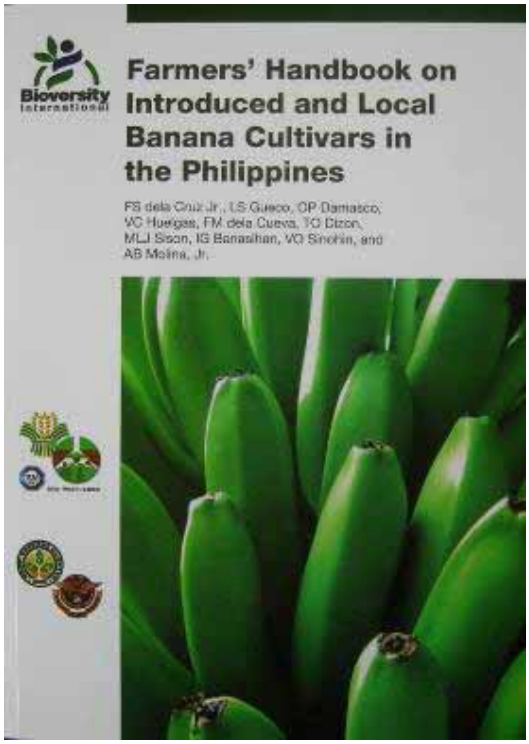
Draft Manuscripts

1. Sensory evaluation of local and introduced banana cultivars
2. Taste test of the different preparations of introduced banana and local cultivars
3. Resistance of local and introduced banana cultivars to banana bunchy top
4. Evaluation of Local and Introduced Banana Cultivars to Nematodes
5. Reaction of local and introduced banana cultivars to black Sigatoka
6. Role of Asymptomatic Banana Plants and Alternate Hosts on the Spread of Banana Bunchy-top Disease
7. Mechanism of Resistance to banana bunchy top virus (BBTV)

Catalogue/Brochure



1. dela Cruz, FS, Jr., LS Gueco, OP Damasco, VC Huelgas, IG Banasihan, RV Lladones, I Van den Bergh and AB Molina. 2007. *Catalogue of introduced and local banana cultivars in the Philippines: Results of a demonstration trial by the Institute of Plant Breeding*, University of the Philippines Los Baños. IPB-UPLB, Bioversity International and DA-BAR, Philippines. (63 pp).



2. dela Cruz, FS, LS Gueco, OP Damasco, VC Huelgas, FM dela Cueva, T O Dizon, MJ Sison, IG Banasihan, Vida Grace O. Sinohin, and Agustin B. Molina, Jr. 2008. Farmers' Handbook on Introduced and Local Banana Cultivars in the Philippines. DA-BAR. 67 pp.

Brochure

Growing different kinds of bananas (A Brochure)

Oral presentations

dela, Cruz, FS Jr, LS Gueco, OP Damasco, VC Huelgas, FM dela Cueva, TO Dizon, IG Banasihan, JT Oliver, VGO Sinohin and AB Molina, Jr. 2007. *New Cultivars, New Options: The Potential of Introduced Bananas.* Paper presented during the Annual Scientific of the Crop Science Society of the Philippines. Grand Hotel, Iloilo City. May 2008

Poster presentations

dela, Cruz, FS Jr, LS Gueco, OP Damasco, VC Huelgas, FM dela Cueva, TO Dizon, IG Banasihan, VGO Sinohin and AB Molina, Jr. 2007. Introduced Banana: New Cultivars, More Options for Banana Growers. 30th Annual Scientific Meeting of the National Academy of Science and Technology (NAST). The Manila Hotel, Philippines. 10 July 2008

dela, Cruz, FS Jr, LS Gueco, OP Damasco, VC Huelgas, FM dela Cueva, TO Dizon, IG Banasihan, JT Oliver, VGO Sinohin and AB Molina, Jr. 2007.

New Cultivars, New Options: The Potential of Introduced Bananas. 15th National Fruit Symposium. Sponsored by the Philippine Fruit Association (PFA). Bureau of Soils and Water Management, Diliman, Quezon City. 6-8 November 2007

dela Cruz, FS, Jr., LS Gueco, VC Huelgas,, FM dela Cueva, OP Damasco, IG Banasihan and AB Molina. 2007. Performance of introduced banana hybrids and landraces in the Philippines. Poster paper presented during the Annual Scientific Conference of the Crop Science Society of the Philippines held at DAP, Tagaytay City, Cavite, Philippines. 13-15 January 2007.

dela, Cruz, FS Jr, LS Gueco, VC Huelgas, TO Dizon, FM dela Cueva, OP Damasco, IG Banasihan, RV Lldones, MM Cabanig and AB Molina, Jr. 2006. Selection of Outstanding Banana Cultivars. 36th Annual Scientific Conference of the Crop Science Societies of the Philippines held at Legend Hotel, Puerto Pricesa City, Palawan, Philippines. 8-12 May 2006.

dela Cueva, FM, EG Dinglasan, TO Dizon, FS dela Cruz, Jr., OP Damasco, LS Gueco, and AB Molina, Jr. Role of Healthy-Looking Banana and Alternate Hosts in the Spread of Banana Bunchy Top Disease (BBTD). 36th Annual Scientific Conference of the Crop Science Societies of the Philippines held at Legend Hotel, Puerto Pricesa City, Palawan, Philippines. 8-12 May 2008.

dela Cueva, FM, TO Dizon, FS dela Cruz, Jr., and AB Molina, Jr. 2006. Comparative reactions of introduced and local varieties of banana to banana bunchy top disease. 37th PMCP Anniversary and Scientific Meeting. Grand Regal Hotel, Davao City. 2-5 May 2006

Dizon, TO, FM dela Cueva, FS dela Cruz, Jr., OP Damasco and AB Molina Jr. 2007. Reactions of local and introduced banana cultivars and hybrids to black Sigatoka and banana bunchy top virus. 38th PMCP Anniversary and Scientific Conference, Bohol Tropics Resort, Tagbilaran City, Bohol. Pest Management Council of the Philippines (PMCP). 20-23 March 2007

Herradura, L.E., Ma A. Lobres, I. Van Den Vergh, D. De Waele and R. Davide.2008. Resistance of Papua New Guinean Musa Genotypes to Radopholus Similis. Presented in the Pest Management Council in the Philippines. Puerto Princesa City, Palawan.

Arcelo, M.M., M.A. Alforque, C.E. Soguilon and A.G. Yebes. 2008. Banana Pseudostem Weevil Infestation in Region XI. Presented in the Pest Management Council in the Philippines. Puerto Princesa City, Palawan.

Herradura, L.E., M. A. Alforque and Ma A. Lobres.2003 Banana Streak Badnavirus in the Philippines. Presented during the 17th regional Symposium on RDE Highlights. SMARDEC Annual review. USEP, Bo. Obrero, Davao City

Huelgas, VC, dela Cruz, FS Jr., LS Gueco, TO Dizon, FM dela Cueva, OP Damasco, IG Banasihan and AB Molina. 2007. Can bananas be replaced? Poster paper presented during the 37th Annual Scientific Conference of the Crop Science Society of the Philippines held at DAP, Tagaytay City, Cavite, Philippines on 13-15 January 2007.

Exhibit Materials

1. New Cultivars, New Options for the Banana Farmer: FHIA 25
2. New Cultivars, New Options for the Banana Farmer: FHIA 23
3. New Cultivars, New Options for the Banana Farmer: FHIA 21
4. New Cultivars, New Options for the Banana Farmer: FHIA 17
5. Diversity of Local Banana Varieties: Cardaba

Awards received

1. Poster on "Introduced Banana: New Cultivars, More Options for Banana Growers" won the Best Scientific Poster Award (Agricultural Sciences category) during the recently held 30th Annual Scientific Meeting of the National Academy of Science and Technology (NAST) at The Manila Hotel, Philippines last July 10, 2008
2. Poster on "New Cultivars, New Options: The Potential of Introduced Bananas" won 2nd Best Poster Award 15th National Fruit Symposium sponsored by the Philippine Fruit Association held at the BSWM, Diliman, Quezon City 6 November, 2007
3. Plaque of Recognition awarded to Bioversity International (Commodities for Livelihoods) in partnership with BAR as 2008 NAST Agricultural Science Best Scientific Poster for the paper "Cultivars, New Options: The Potential of Introduced Bananas" given during the 21st BAR Anniversary and Agriculture and Fisheries Technology Commercialization Forum and Exhibition held at the Megatrade Hall 2, SM Mega Mall, Mandaluyong City , August 21, 2008.

Trainings Conducted

1. Training on Nursery and Field Management of In-Vitro Propagated Bananas. September 18 – 20, 2007. Bioversity International Philippine Office, IRRI, Los Baños, Laguna.
   Participants: National Tobacco Administration (NTA) Researchers and Research Technicians

2. Training on Field Management of In-Vitro Propagated Cardaba. February 2008. PGMA Multiline Food Processing Plant, Santa, Ilocos Sur.
   Participants: Tobacco farmers from 7 Ilocos Sur municipalities; NTA

Research Technicians

3. Training on Field Management of In-Vitro Propagated Cardaba. May 6 – 8, 2008. Candon City Municipal Hall, Candon City, Ilocos Sur

   Participants: Tobacco farmers from 6 Ilocos Sur municipalities; NTA Research Technicians

4. Training on Field Management of In-Vitro Propagated Cardaba. May 6 – 8, 2008. Vigan City, Ilocos Sur

   Participants: Tobacco farmers and NTA Research Technicians

7. SUMMARY AND CONCLUSION

Two National Repository, Multiplication and Dissemination Centers (NMRDC) were established in the Philippines: one at the National Plant Genetic Resources Laboratory of the Institute of Plant Breeding, Crop Science Cluster, College of Agriculture, UP Los Baños and other at the Davao National Crop Research and Development Center (DNCRDC) at the Bureau of Plant Industry, Department of Agriculture. These centers serve as the source of introduced and local cultivars for distribution to researchers, students, farmers and other interested individuals.

At UPLB, 30 banana cultivars, composed of 23 introduced and 7 local cultivars are maintained as shoot cultures while at BPI, 29 cultivars consisting of 25 introduced and 4 local cultivars are maintained in vitro. At BPI, the cultivars are also maintained in the field for characterization. In addition, selected cultivars are maintained in pots inside an insect-proof screenhouse to serve as back up of the cultivars maintained in in vitro and in the field and foundation stocks. Regular virus indexing was conducted every six months and after 3 years of maintenance, the materials are still free of the bunchy top virus.

The different introduced and local cultivars were distributed to State colleges and universities (SCUs), farmers and farmers' groups, Department of Agriculture and other government agencies, Municipal Agricultural Offices (MAO), research projects and other interested individuals. At UPLB, a total of 18,459 planting materials were distributed, both as in vitro plantlets and ready-to-plant materials. At BPI, planting materials were also distributed to private companies (Stanfilco, Lapanday, Unifruiti) as foundation stocks for future disease and agronomic field evaluation.

Demonstration fields were set up at UPLB (2 trials) and BPI Davao for morphological characterization, agronomic and yield evaluation, as well as disease evaluation. Farmers' trials were also established in 4 sites in Luzon (Laguna, Isabela, Albay and Nueva Viscaya), and one site in Mindanao (Bukidnon). Results indicate that among the cultivars tested, FHIA 25, FHIA 17 and FHIA 23 show good potential because of higher bunch yield than the local cultivars. In addition, the introduced cultivars showed resistance to common diseases such as bunchy top and sigatoka. Sensory evaluation proved that the potential of these introduced cultivars (particularly the FHIAs) was as raw materials for processed products such as banana chips and banana cake.

From the results generated, a Catalogue of Introduced and Local Banana Cultivars in the Philippines and Farmers' Handbook of Introduced and Local Banana Cultivars were published. One (1) oral presentation, 11 poster papers and 5 exhibit materials were presented in different meetings/symposia. The poster on "Introduced Banana: New Cultivars, More Options for Banana Growers" won the Best Scientific Poser award during the 30th Annual Scientific Meeting of the National Academy of Science and Technology (NAST) in July 2008. A Plaque of Recognition was also given by BAR to Bioversity International for winning this award during

the 21st BAR Anniversary and Agriculture and Fisheries Technology Commercialization Forum and Exhibition in August 2008.

The project also conducted four (4) trainings on Training on Nursery and Field Management of In-Vitro Propagated Bananas in Los Baños and 3 municipalities of Ilocos Sur.

8. RECOMMENDATIONS

1. Scaling-up of the utilization of selected varieties, particularly in Northern Luzon, where the introduced cultivars have gained acceptability in terms of yield, resistance to major diseases and potential as fresh fruit (FHIA 17) and as banana chips (FHIA 21).

2. Bioversity to propose a second phase project to develop a scaling-up model elucidating the components of both social-cultural and economical elements of a sustainable integration of these new cultivars in a crop diversification model for food and income alleviation of small-scale farmers.

3. Publication of handbook/manual/monograph on the agronomic and yield performance, and reaction of the introduced varieties to common diseases as well as publication of draft manuscripts in refereed journals or as popular articles.

4. The current model on the establishment of National Repository, Multiplication and Dissemination Centers (NRMDC) may be recommended for further validation in other countries.

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10. APPENDICES

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